POWER

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"AS IS"

By RUFUS T. STROHM

It takes a lot of brains, you'll grant,
In this advanced, enlightened age,
To manage any power plant
That's shy on meter, chart and gage;
And many a man must sink or swim
By what he knows about his biz;
That's why I twang my lyre to him
Who runs his plant with things "as is."

No daily records go to show
How many tons of coal he burns,
He'll tell you that he doesn't know
The speed at which his engine turns;
He cannot say what cost obtains,
Nor what efficiencies are his,
But yet the simple fact remains,
He makes it pay with things "as is."

He owns a brand of common sense
That stands him in the best of stead,
And years of hard experience
Have taught him how to use his head;
But yet his hair is streaked with gray,
And wrinkles gather on his phiz,
Because he daily plugs away
And does his best with things "as is."

No apparatus hides the wall,
No piles of records mount on high;
He has no instruments at all
On which his judgment may rely;
His brain alone must scheme and plan
To keep the wheels and shafts a-whiz;
And so I rise to laud the man
Who gets along with things "as is."

Hershey Chocolate Company's New Power Plant

Plant laid out for 7,500 kilowatts at 80 per cent power factor, in four 2,300-volt units, and ten water tube boilers each having 7,444 square feet of heating service. Two 1,250-kilowatt 80 per cent power-factor turbo-generators and four boilers installed. Bleeder-type turbines are used and are equipped with surface condensers. Boilers can be operated up to 175 per cent normal rating continuously on natural draft and for short periods up to 200 per cent. Coal is distributed by a weighing larry to stoker hoppers. Arrangements have been made to obtain very complete records of operation.

HERSHEY, PA., situated in the Lebanon Valley about twelve miles east of Harrisburg, on the Philadelphia & Reading Railway, is a model industrial community, and the Hershey Chocolate Co.'s works at this place are the largest of their kind in the world. The new power plant (Figs. 1 and 2) of this company was built to satisfy the rapidly increasing factory requirements, as well as to meet the growing needs of the Hershey Transit Co. and the town of Hershey itself. The chocolate factory requires, not alone a considerable amount of electrical power, but live steam, refrigeration, compressed air, and water in large quantities for many purposes. About 42 miles of interurban electric railway is operated by the Hershey Transit Co., and all the power for transit purposes is supplied from the Hershey plant. Before the new power plant was built, power requirements of the Hershey properties were supplied by a steam-engine-driven plant, operating in conjunction with a Diesel-engine installation. The old steam plant consisted of sixteen horizontal return-tubular boilers and six 4,100-sq.ft. and one 10,130-sq.ft. Edge Moor boilers; two cross-compound condensing engines direct-connected to 2,300-volt alternating-current generators and 575-volt direct-current generators, aggregating 1,125 kva. in direct-current power and 900 kw. in alternating-current power; one non-condensing piston-valve engine driving a 150-kw., 575-volt direct-current generator; four non-condensing units of a combined capacity of 425 kw. and one 400-kw. 250-volt cross-compound Corliss condensing unit; two 40-ton refrigerating machines; and two 164-ton refrigerating machines. The Diesel-engine plant comprises six 3-cylinder, 250-hp. engines direct-connected to 150-kw. 230-volt direct-current generators, and in the same plant are installed two motor-driven 65-ton refrigerating machines.

A separate power plant is provided for the planing mill and box factory. This plant, which comprises two 312-kva. units and burns only sawdust, shavings and hogged wood refuse, supplies all the power required for the wood-working establishment and some additional power besides, the surplus being delivered to the main steam-engine plant, with which the box-factory plant is connected by a tie line.

Located on Spring Creek is the new power plant, this site having been selected for its advantages as to water supply, coal delivery and storage, and ashes disposal; also because it was desirable to keep the dust and dirt incidental to the handling of coal and ashes as far away from the manufacturing departments as was compatible with the economical supply of power, steam and refrigeration to these departments.

The new power-house building is approximately 128 ft. wide by 165 ft. long, of steel-frame monitor-type construction, with concrete foundation walls, brick curtain walls, terra-cotta cornice work, concrete floors and roof, and ventilated steel sash. A brick wall divides the building longitudinally, separating the boiler room from the turbine room. Both boiler-room and turbine-room operating floors are on the same level and at an elevation of 16 ft. above the basement floor, which is substantially at the outside grade. In the turbine-room basement are located the condensers and condenser auxiliaries, water-supply pumps, boiler-feed pumps, air compressor, concrete switch and bus structure, etc., while in the boiler-house basement are the

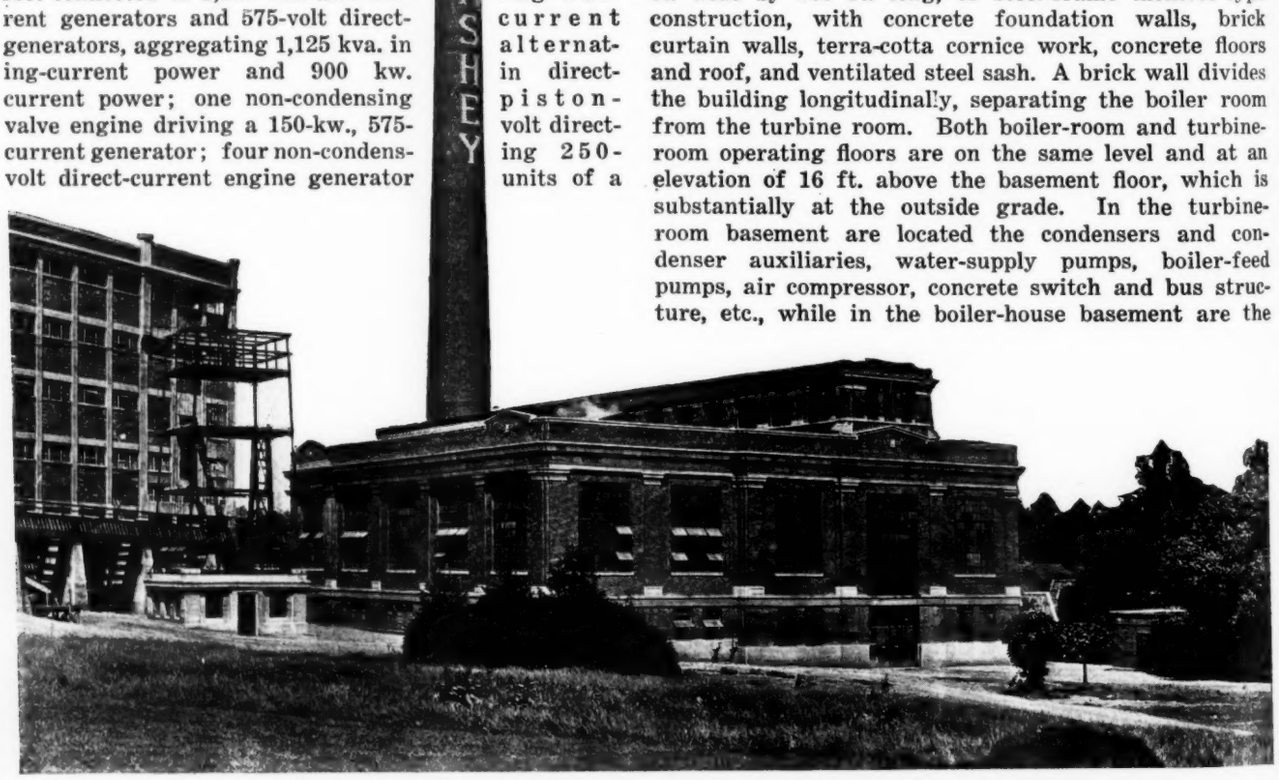


FIG. 1. AN EXAMPLE OF BEAUTY AND UTILITY COMBINED IN POWER-PLANT DESIGN

ash hoppers and ash-disposal means described later on. The main boiler flues also extend through the basement, one of the flue walls forming the division between the turbine and boiler-room sections (see cross-section, Fig. 5). A steel-plate coal bunker of 700-ton capacity is suspended from heavy steel columns on either side of the fireroom space, and from this bunker the coal is drawn into a weighing larry and discharged into the stoker hoppers, Fig. 6.

Considerable attention has been given to the architectural appearance of the various buildings in Hershey, and many of them have real artistic merit. As the new power plant is in a conspicuous location and surrounded by lawns and gardens, an effort has been made to give the buildings a dignified and pleasing appearance (see Figs. 1 and 2), as well as to accommodate it to its intended uses. The buff-brick walls and red-tile floor of the turbine room and the well-designed lighting system all add to the appearance of the interior of the building (Fig. 3). Special attention has been given to securing good natural light and ventilation in both the boiler and turbine rooms.

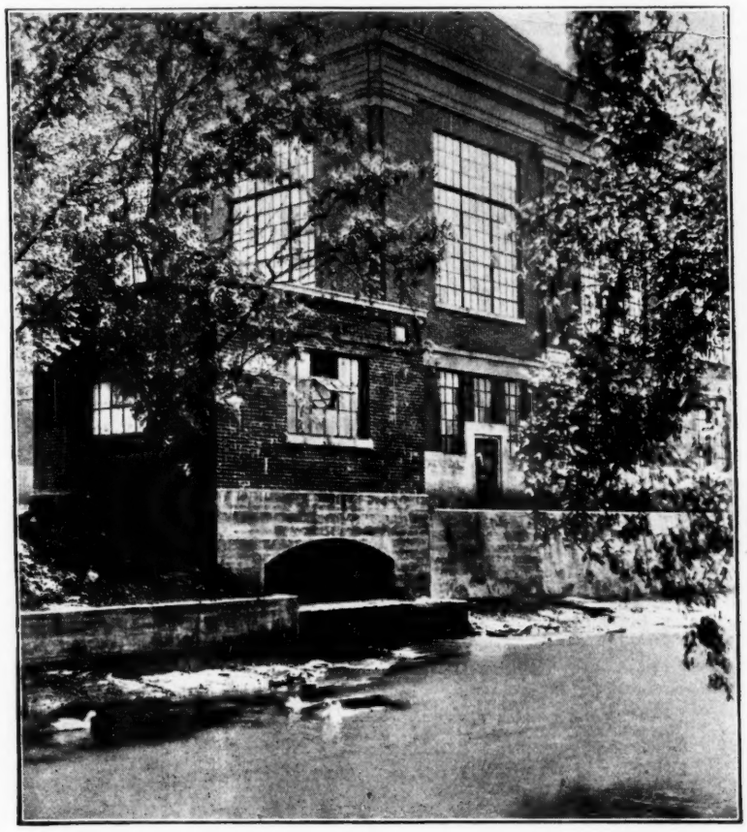


FIG. 2. NOT ONLY ONE OF NATURE'S BEAUTY SPOTS, BUT ALSO THE CONDENSER CIRCULATING-WATER INTAKE

The boiler room of the new plant was designed to accommodate ten boilers having 7,444 sq.ft. of heating surface each, set singly and arranged in two rows, with a common bunker and fireroom space between them. So far, only four of these boilers have been installed. While five units of this size would serve all power apparatus likely to be installed in the new plant, the ultimate intention is to provide sufficient boiler capaity to operate the old steam-engine plant as well as the new turbine plant, and to supply all live steam required for various purposes about the factory. In the turbine room is provided space for four turbo-generator units, two of which are now installed and equipped with surface condensers; two 100-ton refrigerating machines, not yet installed; six water-supply pumps; two fire pumps, an air compressor, etc.; besides feed-water heaters, meters, feed pumps, switchboard, bus and switch structure, transformers and other station auxiliaries.

Outside the main power-house building an intake screen house (Fig. 2) and a lightning-arrester house are provided, and on top of the latter a steel distributing tower is erected, which can be seen at the left-hand corner of the plant in Fig. 1.

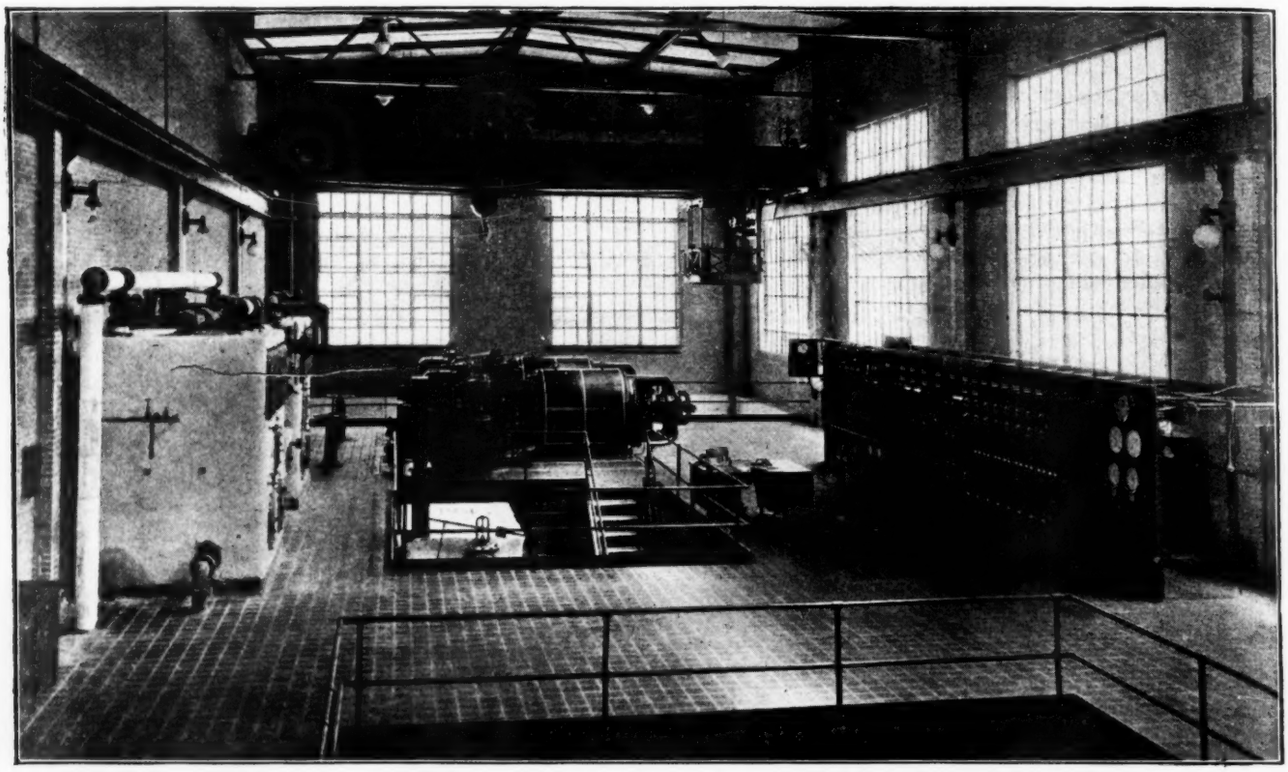
A covered passageway, or tunnel, 12-ft. wide connects the power-house building with the manufacturing plant, and through this tunnel the various steam, exhaust, air and water-supply lines from the new power plant are extended. The roof of the connecting passageway, which is of very heavy construction, serves as a platform for moving into the power house heavy machinery delivered to the plant on the high trestle siding, on which the coal is received. A 25-ton electrically operated gantry crane is provided over this siding for unloading machinery from cars and lowering it to the platform previously referred to. A concrete track hopper and crusher house is provided between two of the piers of the coal siding, and in the crusher house below the track hopper are installed the feeder and the crusher which delivers the coal to a pivoted bucket conveyor which delivers it to the coal bunkers. Two General Electric Co. bleeder-type turbo-generators are now installed, in which steam for process purposes is bled from the turbine, after it has passed through the first stage wheels, at a pressure of 7 lb. and the remaining steam is discharged to the condenser. The pressure between the first and second stages is regulated by a gridiron valve, which controls the steam to the second-stage nozzles. These units are three-stage machines rated at 1,250 kw. at 80 per cent power factor, 2,300 volts three-phase 60-cycles, and have direct-connected exciters. The guaranteed water rate at full load, with steam at 175 lb. gage and 100 deg. F. superheat, giving a total temperature of 478 deg. F., expanding to a vacuum of 28 in. of mercury, is 16.2 lb. per kw-hr. A 50-kw. 125-volt auxiliary exciter, connected to a turbine through herringbone reduction gears, has been provided as a spare and as an emergency source of energy for the station-lighting system.

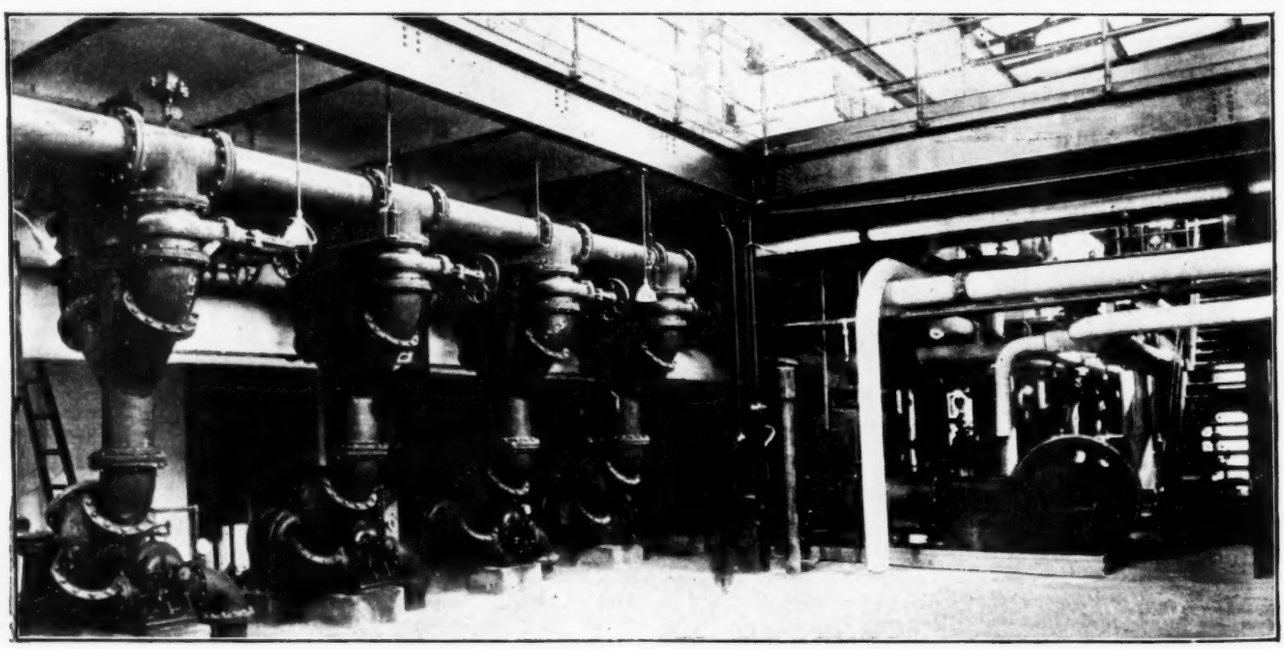
Each of the turbines is connected to one 2,620-sq.ft. surface condenser, with engine-driven Rotrex air pump and centrifugal circulating pump mounted on one base-plate. As the air pump will not discharge against a head in excess of 5 ft., a rotary pump connected to the air-pump shaft is provided to pump the condensate into the feed-water heaters, which are on the floor above. The condensing equipment is designed to produce a vacuum of 28 in., corrected to a 30-in. barometer, with

70-deg. water when condensing 20,000 lb. of steam per hour. With a load of about 100 kw. and cooling water leaving the condenser at 60 deg. F. a vacuum of 29.38 in. was obtained, showing a terminal difference between the entering steam and leaving water of 5 deg.

Four 10-in. 2,400 gal. per min. centrifugal pumps, direct-connected to 50-hp. induction motors, furnish water to the barometric condensers in the milk-evaporating department and to the surface-condenser units in the old power plant. The four pumping units (shown on the left, Fig. 4) discharge into a special three-branch connection controlled by valves so that the different pumps may be connected to the discharge lines in any manner desired.

The boiler-feed pumps in this plant are 3-in. 3-stage, 175 gal. per min. centrifugal units, directly connected to 71-hp. 2,800 r.p.m. turbines equipped with Foster excess-pressure governors. Two pumps have been installed and a foundation has been provided for a third. New impellers, designed to deliver 250 gal. per min., will replace the present impellers when the requirements of the plant make larger pumps necessary.





FIGS. 3 AND 4. VIEWS ABOVE AND BELOW TURBINE-ROOM FLOOR

The four pumping units, shown in lower left-hand corner, discharge into a special three-branch connection controlled by valves so that the different pumps may be connected to the discharge lines any way desired.

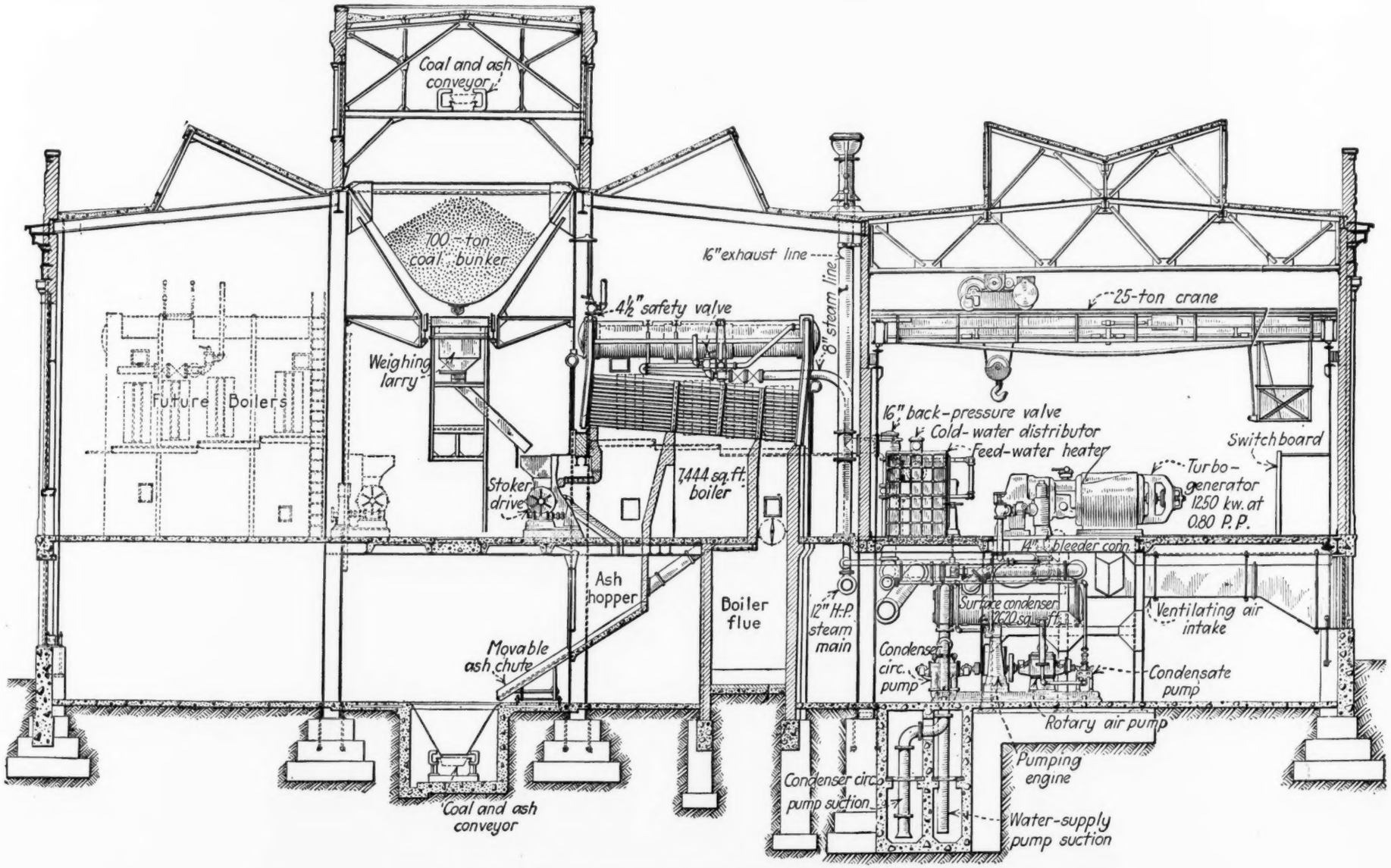


FIG. 5. CROSS-SECTION THROUGH TURBINE ROOM AND BOILER HOUSE

Plant space has been provided for ten boilers having 7,444 square feet of heating surface each, equipped with mechanical stokers operating on natural draft; 4 turbo-alternators of an aggregate capacity of 7,500 kilowatts; two 100-ton refrigerating machines; 6 water-supply pumps; 2 fire pumps; an air compressor and other auxiliary machinery. The 2,300-volt switch and bus structure is located in the basement. Coal distributed from bunkers to stoker hopper by a one-ton weighing lorry. Bucket conveyor delivers coal to bunkers and removes the ashes.

Two 4,000-hp. feed-water heaters are provided and are equipped with a dividing box to insure a proper distribution of water between the two units. The hot water from the heaters flows through and is metered by a V-notch meter located below the heaters and above the feed pumps.

The switchboard, which is on the main operating floor, is of the remote-control type, consisting of 18 two-section plate panels 90 in. high. It is designed to control four 2,300-volt three-phase 60-cycle turbine-driven generators of an ultimate capacity of 7,500 kw.. at 80 per cent power factor, and 10 separate 2,300-volt feeders, also 5 exciter units. A double bus system has been provided to insure continuity of operation and to allow of making repairs and additions while the plant is in operation. The 2,300-volt oil switches and buses are installed in a concrete switch and bus structure in the basement, immediately below the control board. Ten 200-ampere 2,300-volt feeders distribute energy through the factory and to the railway and street-lighting system. Each feeder panel is equipped with indicating ammeters and integrating watt-hour meters. All feeder lines in the new station are brought out under ground to a lightning-arrester house, upon which is mounted a steel distributing tower. The lightning arresters, which are of the oxide-film, indoor type, are mounted around the walls of the lightning-arrester house, and the outgoing lines lead directly up through special roof bushings to insulators on the line tower, whence the lines lead off in different directions.

Two 400,000-circ.mil three-conductor lead-covered cables, laid underground, connect the new station with the old. Each of these tie lines has a capacity of 1,000 kw. An auxiliary bank of three 200-kva. 2,300- to 230-115-volt single-phase transformers has been provided to supply low-voltage power for the motor-driven station auxiliaries and the lighting system for the station.

At present the boiler equipment installed comprises four 7,444-sq.ft. Edge Moor water-tube boilers, of the 4-pass type, having 20-ft. tubes and three drums. The boilers are 13 tubes high by 25 wide, giving a furnace width of 16 ft. 7 in. They are built for 200 lb. working pressure and are equipped with Foster superheaters having 1,200 sq.ft. of heating surface and designed for 100 deg. of superheat. Their front ends are suspended from brackets on the building columns at such a height that the bottom of the front headers are 10 ft. above the floor line. Two Wetzel overfeed, natural-draft stokers are provided for each boiler, each stoker having a grate area of 64 sq.ft. making 128 sq.ft. per boiler, a ratio of grate area to heating surface of 1 to 58.1. Flat suspended arches 3 ft. 6 in. long are provided over each stoker.

In the design of the boiler settings there are several distinctive features worthy of mention. Each boiler is set singly, and the brick side walls are 22 in. thick. The roof of the setting and top halves of the drums are insulated with heat-insulating brick grouted in place, with a cement finish reinforced by light expanded metal. A concrete slab 2½ in. thick, reinforced with

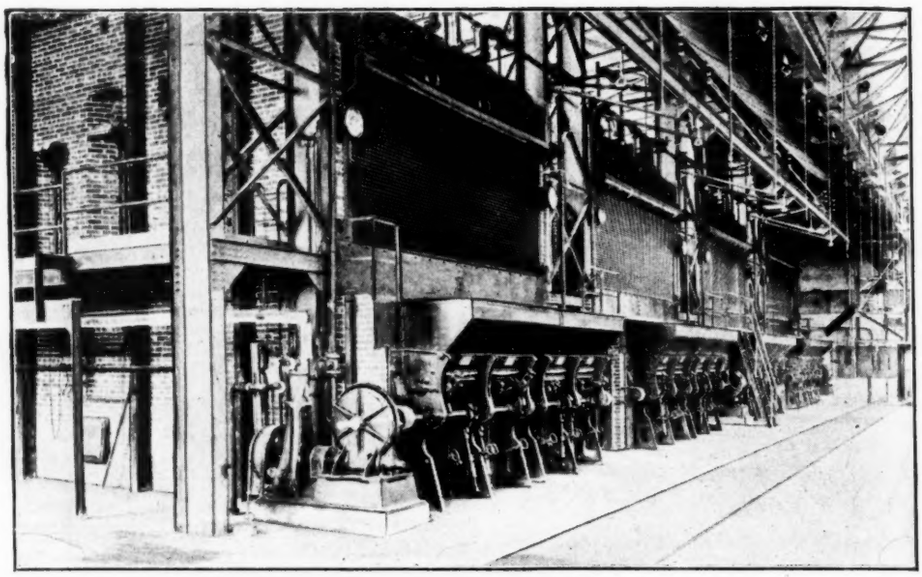


FIG. 6. EACH BOILER EQUIPPED WITH STOKERS OPERATING ON NATURAL DRAFT

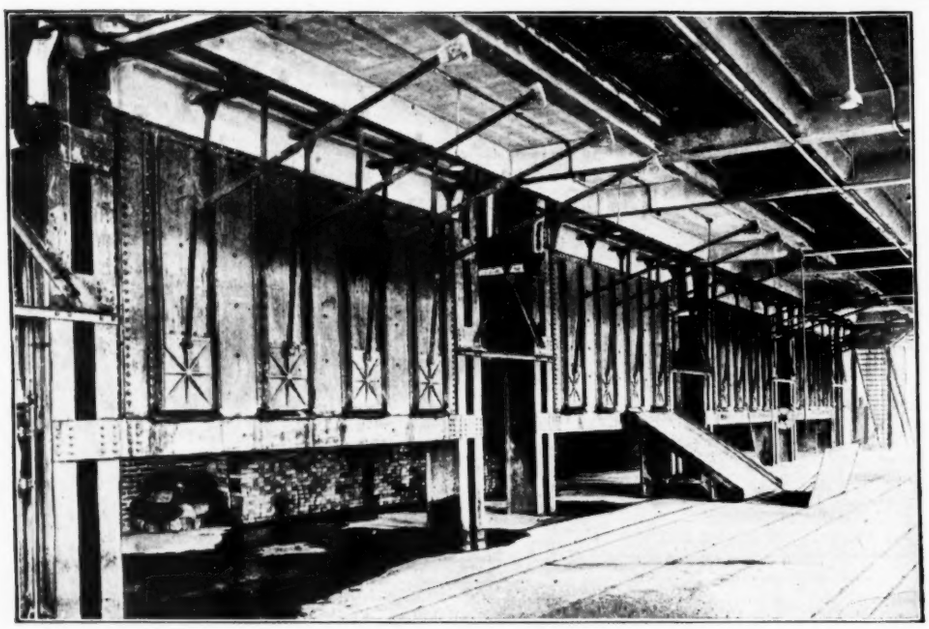


FIG. 7. BOILER-ROOM BASEMENT. ASHES DELIVERED FROM HOPPERS BY TRAVELING CHUTE TO BUCKET CONVEYOR BELOW THE FLOOR

metal lath, is laid over the boiler drums from wall to wall and forms a strong flat roof for walking or working on, besides serving further to reduce radiation. The boilers are equipped with soot blowers, but arrangements are made for blowing the tubes by hand, and platform gratings are provided between and in the rear of all boilers, at a suitable height for cleaning tubes.

Gases from the fourth pass of the boilers discharge downwardly into a brick flue 6 ft. 6 in. wide by 14 ft. 7 in. high, leading to a radial-brick chimney of special design, 10 ft. 6 in. diameter by 250 ft. high, built of dark-red brick, with octagonal brick base to match the brickwork of the power-house building. The chimney is of ample capacity for affording the necessary draft and to remove the gases from the boilers when operated at 200 per cent of rating. It will give a draft at the base of 1.3 in. to 1.5 in., depending upon the weather conditions. When the boiler plant is fully equipped, it will contain ten boilers and a second chimney will then be built.

Coal and Ashes Handling

Coal for this plant is received on a concrete trestle-siding about 35 ft. high. Between the two piers opposite the longitudinal center line of the boiler house a concrete track hopper and crusher house have been constructed, the crusher house being directly below the track hopper. Coal is fed from the track hopper to a single-roll crusher, by a double-end reciprocating-plate feeder. Crushed coal flows by gravity into a pivoted-bucket conveyor having 24- x 24-in. malleable-iron buckets, and is delivered by this conveyor to storage or into the bunker above the boilers, as desired. Arrangement is made for reclaiming coal from the storage pile by the conveyor, the lower run of which extends through a concrete-walled tunnel having a roof slab in which openings, controlled by special feeder gates above the conveyor, are provided.

The conveyor, which is 274 ft. long, horizontally, has a lift of 64 ft. and a capacity of 60 tons per hour. It is driven by a 20-hp. motor and is used for handling ashes as well as coal. Ashes and refuse from the hoppers underneath the stokers are discharged through 24- x 24-in. vertically sliding, counterweighted gates, onto a movable apron (see Fig. 7) and thence through heavy-bar gratings to the lower run of the conveyor, any clinkers too large to go through the grating being broken up by hand. Excepting when ashes are removed by the conveyor, the gratings are covered by hinged covers of ⅜-in. checkered steel plate.

Water Supply Taken from Spring Creek

A water supply for the new plant, as well as the old one, is taken from Spring Creek, a small stream alongside, across which a low dam has been built to raise the level of the water and afford a better supply at the intake well and screenhouse, located above the power house at the edge of the creek. The intake is protected by a heavy bar screen (Fig. 2), and the water passing through it is further screened by a traveling screen 7 ft. wide, having ½-in. mesh galvanized-wire frames fixed to chains on either side. After passing the screen, the water flows through a 42-in. cast-iron pipe to a suction conduit 42 in. wide, running the length of the turbine room below the basement floor. A discharge-water conduit is built alongside the suction conduit and at the same level, and a 42-in. cast-iron pipe leads from the end of the conduit system to a point below the dam. Both conduits are controlled by cast-iron sluice gates at either end, and by opening the gates at each end of either conduit, any mud accumulating in the conduits can be flushed out and discharged below the dam.

Separate suction pipes from the various condenser-water supply and fire pumps extend into the suction conduit about four feet below the water surface. While the flow of the creek is sufficient to supply the present requirements, when the new plant is increased to its ultimate capacity, the water used by the engine condensers in the old power plant and the barometric condensers in the milk-evaporating department will require to be cooled by spraying, and provision has been made so this can be done without further pumping.

Piping Work and Miscellaneous Details

All headers and leads in the piping system excepting those connecting above the operating floor, are kept in the basement. The high-pressure steam header is of 12-in. pipe, and all valves, fittings and flanges in it and in the boiler leads and main branches are of steel. The auxiliary steam header is 6-in. in diameter, while the auxiliary-exhaust header is of 16-in. pipe. A 20-in. 7-lb. steam line connects with the extraction outlet on the turbines and extends through the basement of the power house and the pipe tunnel to building No. 35, in which the milk-evaporating department is located. A 7-in. 40-lb. steam, and a 3-in. high-pressure steam line also lead to the milk-evaporating department. Some idea of the steam requirements of this department can be gained from the statement that 40,000 gallons of milk are evaporated daily in this plant. One 8-in. and three 12-in. water-supply lines lead from the new plant, also two fire-service lines, one of these being 12-in and the other 10-in. All piping work has been laid out and constructed with a view to securing simplicity of construction and reliability in operation. Sectionalizing valves have been installed, and duplicate pipe systems have been provided where interruption of service might result from the necessity of closing off

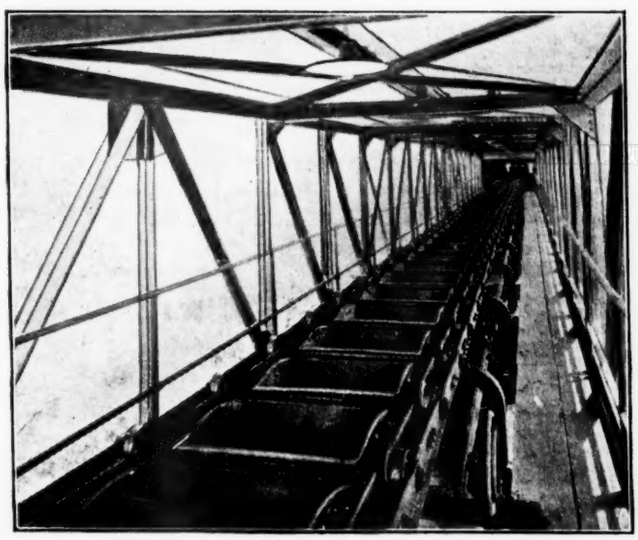


FIG. 8. COAL-AND-ASH CONVEYOR

certain sections of the system. Vanstone joints have been employed on practically all pipe lines 3-in. diameter and larger, and welded outlets and connections have been made wherever practicable, to eliminate fittings and unnecessary joints.

Great care has been exercised in the insulation of all steam and hot-water lines as well as all other parts of the equipment where heat losses would occur. Eighty-five per cent magnesia is used throughout with extra-heavy 10-oz. canvas sewed on over rosin-sized paper. The large fittings are covered with blocks and the small fittings and valves bodies with plastic. In the case of large-size valves both blocks and plastic are used in covering the valves. For more details regarding the heat insulation see the following table.

A complete equipment of pressure and vacuum gages has been provided for all pumps and thermometers and mercury vacuum gages for the condensers. Flow meters have been installed on all the principal steam and water lines, and the recording instruments have been mounted on a slate-panel meter board in the turbine room. Each boiler is equipped with an indicating flow meter and three draft gages mounted in one case and connected to show the draft at boiler damper, furnace draft and draft loss through the setting.

An illuminated master steam gage with graduations on the dial exaggerated within the working range of steam pressure, indicates small variations in steam pressure, so that the firemen may better control the operation of the boilers.

The design of this plant in all its details, including buildings and equipment, was developed by Albert C. Wood, consulting engineer, Philadelphia, Pa. The operation of this and other plants of the company at Hershey is under the supervision of C. V. Glynn, mechanical engineer, who co-operated with Mr. Wood in the construction of the plant and the installation of the various equipment.

DATA ON PRINCIPAL EQUIPMENT IN NEW POWER PLANT OF THE HERSHEY CHOCOLATE COMPANY

BUILDING DIMENSIONS, ETC.

Length of turbine room, inside	131 ft., 4 in.
Width of turbine room, inside	45 ft., 9 in.
Length of boiler room, inside	136 ft., 4 in.
Width of boiler room, inside	77 ft., 6 in.
Distance basement floor to operating floor	16 ft., 0 in.
Distance turbine operating floor to lower chord of roof truss	25 ft., 6 in.
Ratio of boiler-heating surface to boiler-house floor area	0.071 to 1
Width of alleyway between boilers	5 ft., 9 in.
Width of passageway behind boilers	5 ft., 3 in.
Distance between boilers across firing aisle	22 ft., 0 in.

BOILERS AND SUPERHEATERS

Manufacturer of boilers	Edge Moor Iron Co.
Number of boilers (ultimately 10)	4 installed
Steam drums, three	35½ in. O.D.; 7/8 in. thick shell plates
Tubes, Number of, 332; hot drawn seamless; No. 9 gage; 20 ft. long	
Number of passes	4
Water heating surface per boiler	7,444 sq.ft.
Boiler working pressure	200 lb.
Superheaters	Power Specialty Co.
Square feet of heating surface	1,200
Ratio of superheater surface to boiler heating surface	1 to 6.25
Superheater performance:	
Boilers operated at normal rating, steam containing not over 1 deg. moisture, superheat 100 deg. F.	

STOKERS

Kind of stoker	Wetzel Mech. Stoker Co.
Width of grate per stoker	7 ft., 7 in.
Length of grate (projected)	8 ft., 6 in.
Number of stokers per boiler	2
Area of grate per boiler	128 sq.ft.
Ratio of water-heating to grate surface	58.1
Stoker engines, three	5 in. x 5 in.
Proximate analysis of coal upon which stoker performance is based:	
Volatile matter	18–21 per cent
Fixed carbon	66–76 per cent
Ash	6–12 per cent
Sulphur	1–2½ per cent
Heat value, dry basis, B.t.u.	13,600–14,600
Efficiency performance of stokers:	
Per cent of boiler rating	150
Per cent of CO_2 in escaping gases (min.)	12
Per cent of CO (max.)	0.3
Average furnace draft	0.4 in.
Fusing point of ash (min.)	2,600 deg. F.
Capacity performance of stokers:	
150 per cent boiler rating continuously.	
175 per cent boiler rating for three hours.	
200 per cent boiler rating for one hour.	

BOILER SETTINGS

Height of bottom of front header from floor	10 ft. 0 in.
Height of top of front header from floor	21 ft., 1½ in.
No. 1 fire brick "Woodland"	Harbison-Walker Refractory Co.
No. 2 firebrick "Widemire"	Harbison-Walker Refractory Co.
Insulating brick "Nonpareil"	Armstrong Cork & Insulation Co.
Volume of combustion chamber	1,000 cu.ft.
Volume of combustion chamber per sq.ft. of active grate area	7.82 cu.ft.
Arches, M. H. Detrick Co., flat suspension, 2 per boiler, 3 ft. 6 in. long.	

MAIN FLUES

Number of flues	2 (brick)
Number of boilers served by each flue	5
Width of flue (uniform throughout length)	6 ft., 6 in.
Height of flue at chimney end	14 ft., 7 in.
Height of flue at first boiler	11 ft., 7 in.
Area of flue at chimney end	94.8 sq.ft.
Ratio of flue area at chimney to total grate surface	1 to 6.75

CHIMNEY

Built by	Alphons Custodis Chimney Construction Co.
All brick for chimney manufactured by	Auburn Shale Brick Co.
Circular section, radial brick; base common dark-hard brick.	
Inside diameter at top	10 ft., 6 in.
Height	250 ft.
Wall thickness at top	10½ in.
Taper	3⅝ per cent.
Weight of brick chimney	1,208 tons
Weight of concrete foundation	492 tons
Area of chimney inside at top	86.59 sq.ft.
Ratio of chimney area to grate surface	1 : 7.4
Chimney designed to withstand a wind pressure varying from 20 lb. per sq.ft. of projected area at the top to 15 lb. per sq.ft. at the bottom, without tension in the brickwork on the windward side, and with a maximum stress of 200 lb. per sq.in. in compression on the leeward side.	
Draft at base 1.3 to 1.5 in., depending on weather conditions.	

COAL- AND ASH-HANDLING EQUIPMENT

Manufacturers	Jeffrey Mfg. Co.
Double-plate feeder, 27 in. wide x 15 ft., 6 in. long, capacity, tons of coal per hour	60
Motor; induction, 5-hp., 1,160 r.p.m.	
Single roll crusher, 30 in. x 30 in., 50 r.p.m.; capacity, tons of coal per hour	60
Motor: Induction, 40-hp	575 r.p.m.
Pivoted bucket conveyor, 24 in. x 24 in. M.-I. buckets; capacity, 60 tons of coal per hour and 40 tons of ashes per hour.	
Motor; induction, 20-hp	870 r.p.m.
Traveling weigh larry; 3-hp. motor, capacity	2,000 lb.
Reinforced-concrete track hopper, capacity	195 tons
Reinforced-concrete ash hopper, capacity	194 tons

COAL BUNKER

Steel-plate suspension type in boiler house ¼-in. steel side plates, ⅜-in. iron bottom plates, capacity	700 tons
Capacity per lineal foot	6 tons

VALVES, SOOT BLOWERS, ETC.

Diamond soot blowers, 8 units per boiler	Power Specialty Co.
Automatic non-return valves, boiler leads	Lagonda Mfg. Co.
Feed-water valves	Hancock Inspirator Co.
Blow-off valves, "Dura" valves and "Victor" cocks	Lunkenheimer Co.
Steel globe valves, stop and throttle	Edward Valve & Mfg. Co.
Bronze globe valves, stop and throttle	Hancock Inspirator Co.
Steel-body gate valves, list 63½	Chapman Valve Mfg. Co.
Iron-body gate valves, lists 42½, 24, 59½	Chapman Valve Mfg. Co.

TURBO-GENERATORS

Manufacturer	General Electric Co.
Number of units (ultimately 4)	2 installed.
Type	Bleeder.
Rating	1,250 kw. at 0.80 P.F.
Number of stages	3
Maximum peripheral velocity	925 ft. per sec.
Radial clearance (min.)	0.25 in.
Blading material:	
First and second stage, manganese bronze.	
Third stage, Monel metal.	
Generator	Three-phase, 60 cycle, 2,300 volts
Ventilation, air	6,000 cu.ft. per min.
Net weight, turbo-generator	47,000 lb.
Exciter: direct-connected	125 volts
Rating	13 kw.
Performance: Operating conditions, 175 lb. gage, 100 deg. superheat, 28 in. vacuum, corrected to 30-in. barometer.	

Kw. Output of Generator	Lb. of Steam per Kw.-hr.
312	23.5
625	18.0
937	16.5
1,250	16.2

DATA ON PRINCIPAL EQUIPMENT IN NEW POWER PLANT OF THE HERSHEY CHOCOLATE COMPANY—CONTINUED

STEAM EXTRACTION PERFORMANCE

Kw. Output of Generator	Lb. per Hr. Extracted at 7-Lb. Gage	Flow to Condenser Lb. per Hr.
500	15,000	3,000
600	20,000	2,250
800	20,000	5,000
1,000	20,000	8,000
1,250	20,000	12,600

CONDENSER EQUIPMENT

Type: surface	C. H. Wheeler Mfg. Co.
No. of units	2
Condensing surface	2,620 sq.ft. each
Tubes ¾-in., No. 18 B.w.g. brass, untinned	12 ft., 0 in.
Condenser surface per kw. of generator rating	2.1
Number of water passes	2
Circulating pump, size	10 in.
Capacity: 2,200 gal. per min. at 250 r.p.m. and total head of	25 ft.
Air and condensate pump	No. 15 Rotrex
Condensate lift pump	Goulds Mfg. Co.
Vertical-engine drive; size	8 in. x 7 in.
Circulating-water velocity	3.8 ft. per sec.
Circulating water per tube	3.95 gal. per min.
Condenser friction head (computed)	4.9 ft.
Condenser performance:	
Pounds of steam per hour	20,000
Temperature of condensing water	70 deg. F.
Vacuum, in exhaust nozzle	28 in.

SWITCHBOARD

Manufacturer	General Electric Co.
Number of panels, two-section	18
Height of panels	90 in.
Capacity at 2,300 volts	9,375 kva.

FEED-WATER HEATERS

Number	2
Manufacturer	Warren-Webster
Size, each	4,000 hp.
Capacity, 40 to 200 deg. F. water per min	2,000 lb.
Cubic contents, each	316 cu.ft.
Water space	179 cu.ft.
Tray area	160.1 sq. ft
Weight, shipping, each	20,000 lb.

FEED-WATER METERING COMPARTMENT

Manufacturer	Yarnall-Waring
Capacity	300,000 lb. per hr.
Number of V-notch weir plates	2
Cubic contents	190 cu.ft.

BOILER-FEED PUMPS

Manufacturer	Earle Gear & Mach. Co.
Number	2
Type and size, centrifugal	3 in., 3-stage
Capacity with present impellers	175 gal. per min.
Ultimate capacity obtained by installing new impellers	250 gal. per min.
Discharge head	230 lb.
Speed	2,800 r.p.m.
Drive, 71-b.hp., turbines	Terry Turbine Co.
Efficiency at specified conditions	45 per cent

FIRE PUMPS

Manufacturer	Earle Gear & Mach. Co.
Number	2
Type and size, centrifugal	6 in., 2-stage
Capacity	1,000 gal. per min.
Discharge head	120 lb.
Speed	2,000 r.p.m.
Drive, 120-b.hp., turbines	Kerr Turbine Co
Efficiency at specified conditions	65 per cent

AIR COMPRESSOR

Manufacturer	Bury Compressor Co.
Size and type, 9 in. and 18 in. x 10 in. and 16 in., compound steam, 2-stage air.	
Capacity, cu.ft. free air per min	350
Discharge pressure	100 lb.
Speed	150 r.p.m.
Weight	16,000 lb

WATER-SUPPLY PUMPS

Manufacturer	De Laval
Number	4
Type, centrifugal, size	10 in.
Capacity	2,400 gal. per min.
Total head	58 ft.
Speed	1,750 r.p.m.
Drive, 50-hp. induction motor.	
Efficiency at specified conditions	75 per cent
Manufacturer	De Laval
Number	2
Type, centrifugal, size	5 in.
Capacity	750 gal. per min.
Total head	150 ft.
Speed	1,750 r.p.m.
Drive, 50-hp., induction motor.	
Efficiency at specified conditions	68 per cent

SPARE EXCITER UNIT

Manufacturer	Westinghouse El. & Mfg.Co.
Size	50 kw.
Turbine, r.p.m	7,200
Generator, r.p.m	1,200
Generator	125 volts, compound wound
Weight	3,340 lb.

HEATING-SYSTEM VACUUM PUMPS

Manufacturer	Worthington Pump & Mch. Corp.
Number	2
Size	8 in. x 12 in. x 12 in.
Capacity, lb. condensate per hr., each	22,000

TURBINE OIL-FILTERING SYSTEM

Manufacturer	Richardson-Phenix Co.
Size	No. 12
Capacity	200 gal. per hr.

TRAVELING CRANE AND TRANSFER TROLLEY

Manufacturer	Toledo Bridge & Crane Co.
Capacity	25 tons
Span	44 ft.
Lift	30 ft.
Main hoist, 10 ft. per min.; drive, 30-hp. motor	
Trolley, 125 ft. per min.; drive, 8-hp. motor	
Bridge, 200 ft. per min.; drive 30-hp. motor	
Weight	54,000 lb.
Trolley for transfer crane, capacity	25 tons
Hoist, 10 ft. per min.; drive, 30-hp. motor	
Trolley, 50 to 60 ft. per min.; drive, 8-hp. motor	
Weight	18,500 lb.

INTAKE SCREEN

Manufacturer	Link Belt Co.
Type	Traveling, motor driven
Effective screening width	6 ft., 8 in.
Screen trays, ¼-in. mesh, No. 12 gage wire.	
Drive	3-hp. motor
Maximum capacity of screen based on velocity of 1 ft. per sec. through screen	

SPECIAL VALVES

Pressure regulating	Foster Engineering Co.
Two 5-in. reducing steam pressure from 200 lb. to 40 lb.	
Two 8-in. reducing steam pressure from 40 lb. to 7 lb.	
Back-pressure valves	Atwood & Morrill
Two 14-in., bleeder steam lines from turbines.	
One 16-in. feed-water heater.	
Atmospheric-relief valves	Atwood & Morrill
Two 8-in. fire-pump turbine exhaust.	
Two 14-in. main turbines free exhaust.	

FLOW METERS AND INSTRUMENTS

Flow meters	Republic Flow Meters Co.
8-in. boiler leads, four 175 lb. gage, 100 deg. superheat 50,000 lb. per hour.	
6-in. steam line, one for process work, 40 lb. gage, 7,500 lb. per hour.	
14-in. steam line, two for process work, 7 lb. gage, 20,000 lb. per hour.	
12-in. water lines, three for water supply to factory, 3,000 gal. per min.	
8-in. water lines, one for water supply to factory, 1,000 gal. per min.	
Draft gages, four 3 in 1	Precision Instrument Co.
Flue-gas collectors, four	Hays
Mercury-column vacuum gages, two	Schaeffer & Budenberg Mfg. Co.
Recording thermometers	Brown Instrument Co.
Pyrometers	Thwing Instrument Co.

PIPING WORK

Underground pipe lines of Class "B," cast-iron pipe.
All other pipe standard full-weight steel, except boiler-feed and blowoff lines, which are of extra heavy steel pipe.
Van Stone joints used on all lines, 4-in. size and larger. Extra-heavy high-hub rolled-steel flanges used on all high-pressure steam lines; extra-heavy high-hub cast-iron flanges on all high-pressure water lines, and standard high-hub cast-iron flanges on all other lines. Screwed joints employed on all pipe work smaller than 4-in.
Welded necks and other welded work employed wherever possible, in order to eliminate fittings.
Piping contractors: M. J. Dougherty Co., Philadelphia, Pa.

PIPE COVERING

85 per cent magnesia throughout, with extra 10-oz. canvas sewed on over rosin-sized paper. Valve bodies, fittings and flanges covered. High-pressure steam-lines 6-in. size and above, covered with double standard thickness; 5-in. to 3-in., inclusive, with 2-in. thick coverings; 2½-in. and smaller with 1½-in. thick coverings.
All low-pressure and exhaust-steam lines, and all hot-water lines covered with standard thickness coverings.
Boiler headers and ends of drums covered with 1½-in. blocks and ½-in. plastic.
Feed-water heaters covered with 1½-in. blocks and ½-in. plastic.
Meter tank covered with 1-in. blocks and ½-in. plastic.

Pipe-covering contractor	Ehret Magnesia Manufacturing Co.
Bus and switch structure, 2,300-volts, 7,500 kw.	United Electric Constr. Co.
Structure-steel and plate work	Shoemaker-Satterthwait Bridge Co.
Building brick	Glen Gary Shale Brick Co.
Steel sash and doors	David Lupton's Sons Co.
Power-house building contractor	John H. Wickersham, Lancaster, Pa.
Consulting engineer	Albert C. Wood, Philadelphia, Pa.

Overload Protection of Motors

By EDGAR P. SLACK
Assistant Electrical Engineer, Underwriters Laboratories

THE 1920 edition of the National Electrical Code is the first to provide definite regulations for the protection of motors, as distinguished from the protection of their supply circuits. Where are cutouts required for motor protection? This article will discuss briefly the rules bearing on this question and the protection of the motor lines. The size of cutouts required will be taken up later. The current in a motor heats the windings, and if a heavy current were allowed to flow in them too long, it might either burn them out or deteriorate the insulation so as to make it unreliable. The object of a cutout is to open up and prevent damage in case of excessive current, just as a safety valve on a steam boiler operates when the pressure gets too high.

How to protect your motors against breakdown through overloads—this is the subject discussed and explained by the author in this and following articles. The use of fuses, circuit breakers and motor starters equipped with overload devices is covered in this issue. The next article will discuss fuse ratings and circuit-breaker overload settings for adequate protection of the motors.

Two general classes of automatic cutouts are used for motor protection—fuses and circuit breakers. Fuses are generally strips of zinc or alloy having a low melting point, and they operate by melting from the heat generated by the current. A special form of fuse known as the thermal cutout has also been developed for motor use, and consists briefly of a heating coil and a fusible link which, when melted, opens by spring pressure and clears the circuit. Circuit breakers usually have a switch member held closed by a toggle movement, and a series coil or solenoid. Under heavy current the solenoid draws up a plunger which strikes the toggle joint and throws the breaker open. The Code requires that "each motor must be protected by an automatic cutout," so that if a heavy current flows, such as might result from an overload, short-circuit or ground, the cutout will open the circuit and save the machine from burning up. An exception is made in the case of small motors, which "may be grouped under the protection of a single set of fuses, provided the rated capacity of the fuses does not exceed 10 amperes and the total wattage of the circuit does not exceed 660." This rule is consistent with other Code regulations, which permit branch circuits loaded to 660 watts to be protected by a single set of 10-ampere fuses. If fuses are used for motor protection, "one fuse must be provided in each conductor." This rule gives a desirable factor of safety, and also, in case of a heavy short-circuit, allows two fuses to blow in series, which makes the performance easier.

If a circuit breaker is used instead of fuses, "one pole must be provided in each conductor" for the same reason as already given for fuses. It is also required that the circuit breaker shall "be so designed that its operation will open all of the conductors simultaneously," thereby entirely clearing the line in case of trouble, except that for direct-current and single-phase alternating-current motors (that is, all two-wire motors) "one single-pole circuit breaker may be used in each conductor or a single-pole circuit breaker in one conductor and a fuse in the other." This rule gives the user a certain amount of choice in selecting equipment, without losing the desired protection. Combining fuses and circuit breakers is not allowed on polyphase motors. In this class of machine it is preferred that the cutouts shall clear the whole motor if excessive current flows in any one phase. If the cutout opened only one line, the phases still connected would then draw a heavier current, which is undesirable.

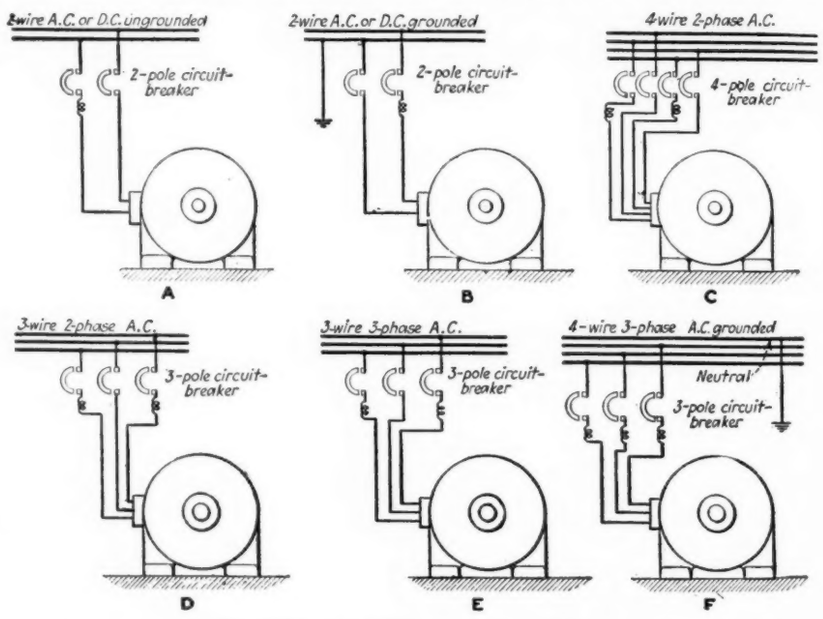


FIG. 1. NUMBER AND ARRANGEMENT OF OVERLOAD TRIP-COILS REQUIRED ON MOTOR CIRCUIT BREAKERS

A—2-wire alternating current or direct current ungrounded: 1 coil (in either conductor). B—2-wire alternating current or direct current grounded: 1 coil (in ungrounded conductor). C—4-wire, 2-phase: 2 coils (one in each phase). D—3-wire, 2-phase: 2 coils (one in each outside conductor). E—3-wire, 3-phase: 2 coils (one in each of any two conductors). F—4-wire, 3-phase grounded: 3 coils (one in each ungrounded wire).

The requirements for overload trip coils of circuit breakers protecting motors are designed to make it impossible for excessive current to flow in any line without energizing at least one trip coil. The number and location of overload trip coils for different types of motors are shown in Fig. 1.

The setting of a circuit breaker can easily be changed so that more current will be required to operate it, thus losing the necessary protection. In order to protect the motor against overloads resulting from tampering by persons ignorant or thoughtless of the hazards involved, it is required that "except on main switchboards, or when otherwise subject to competent supervision, an approved fuse must be provided in each conductor of motor circuits whether an automatic overload circuit breaker is installed or not."

Where a cutout rated over 600 amperes is required, "circuit breakers will be approved in lieu of fuses," because approved inclosed fuses are not made above that rating.

It is common practice to provide circuit breakers or their equivalent as part of motor starters. In the case of autostarters or compensators, the following rule applies: "If an alternating-current starter, when in the running position, opens all of the conductors of the circuit automatically under overload, and is equipped with the proper number of overload trip coils as given above, it may also serve as a circuit breaker." During the starting period alternating-current motors are considered as being sufficiently protected by the cut-outs which are furnished for protecting supply lines.

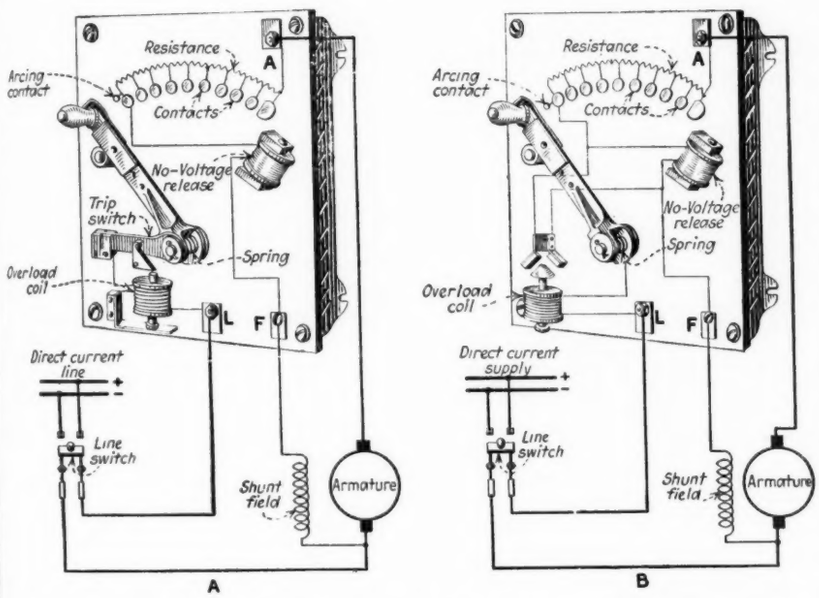


FIG. 2. OVERLOAD RELEASE DEVICES ON DIRECT-CURRENT STARTERS

A—This type trips an auxiliary switch member in the main line, regardless of the position of the starting handle, so that overload protection is afforded during starting. This type of starter is accepted as a circuit breaker. B—This type does not trip free from the starting handle, and the circuit can be broken only when the handle returns to the "off" position. The overload device is inoperative during starting, the handle being held by the operator. An extra cutout must therefore be used with this starter.

In the case of direct-current starters the rule requires that if the overload release device "is inoperative during the process of starting the motor, a separate circuit breaker or set of fuses must be provided." For instance, an overload coil that operates a switch member in the line is accepted as a circuit breaker; such a type is illustrated in Fig. 2A. In another type, shown in Fig. 2B, the overload coil operates to shunt out the retaining or "no-voltage release" coil, which holds the starting arm in the running position. Such a device is inoperative during starting, the starting arm being held by the operator's hand regardless of the retaining coil, and a separate cut-out is required.

Germany Developing Water Power

Quite an extensive hydro-electric project is being undertaken in Germany in the development of the Neckar River. The scheme has been talked about for some time, but now seems to be definitely under way, as an association has been organized at Stuttgart for carrying on the work and financial preparations are being made.

The association, called the "Neckar Aktien Gesellschaft," is organized on the same lines as the so-called mixed co-operative syndicate, that is, a combination of state, communal, municipal and private interests. As in the financing of the Bavarian hydro-electric projects, the majority of the capital required will be obtained by the issuance of obligations for which the Reich will be the principal guarantor. Capital requirements during the next few years are estimated at 950 million marks, while the total capital required for the completion of the scheme will amount to from 1,900 to 2,000 million marks. During the first ten years the Reich and the Württemburg state will voluntarily forego all interest and dividends due on the invested capital; these will be transferred to a special reserve fund established with a view to providing current at a comparatively low rate.

While the ultimate object of the whole enterprise is the canalization of the Neckar and the linking of that river with the Danube, its immediate purpose should be seen in the harnessing of the Neckar and the generating of hydro-electric energy with a calculated output of 70,000 hp. equal to 300,000,000 to 400,000,000 kw.-hr. The whole scheme represents a bold attempt to render large industrial districts in the south of Germany less dependent on outside coal supplies and its success from a revenue-paying point of view will, in a measure, be linked with the future development of the South-German coal market and, above all, inland coal prices and coal taxes.

The entire project, covering the section of the Neckar from Mannheim to Plochingen—a distance of about 210 km.—provides for 25 to 28 dams. It is intended to start building operations at the five best-suited barrages without further loss of time and the first 700 million marks' worth of obligations will shortly be issued. Completion of the scheme in its present form will take from 10 to 13 years. Concessions have been granted for a period of 100 years.

Another big hydro-electric scheme is planned by the Prussian government in the form of a supplement to the state hydro-electric plants on the Weser and the Main, comprising four new plants to be erected on the Fulda at Cuxhaven, Freienhagen, Wahnhausen and Munden, of which only the Eder Valley power station is in operation as yet. Plants already erected and in course of construction on the Weser and Main will yield an aggregate of 66 million kilowatt-hours per year after completion, and the output of the projected Fulda plants is estimated at 69 million kilowatt-hours annually.

The Dual-Combustion Oil Engine

By W. JOHN WALKER, Assoc. M. I. M. E.*

THE dual-combustion engine in its modern form comprises two main types, low- and medium-compression engines, a dual-cycle engine being one where the fuel is burned partly at constant volume and partly at constant pressure. The former type is embodied most distinctly and generally in the Blackstone oil engine, built by Blackstone & Co., Ltd., of Stamford, England, while the latter includes the Crossley, De La Vergne and Vickers engines of the medium-compression, solid-injection class.

The following extract from the description of a Blackstone oil engine is taken from an article in *"The Engineer,"* April 23, 1915:

> The engine had a single cylinder, 15½-in. diameter by 23-in. stroke, giving 94 maximum brake horsepower at 205 revolutions per minute. The test figures show a consumption of 0.465 lb. per brake horsepower-hour at full load, 0.495 lb. at ¾ load, 0.555 at half-load and 0.74 lb. at quarter-load. Compression is approximately 150 lb., and the maximum pressure is below 300 lb. per sq.in. The mechanical efficiency of the engine works out to about 80 per cent.

A typical diagram from this engine is shown in Fig. 1, and in this the "dual" combustion lines are clearly discernible. The spraying device used to attain this end forms the most distinctive feature of the Blackstone engine. A compressor delivers air direct to this spraying valve, and in this respect the engine resembles the Diesel, the initial charge of fuel being delivered into the combustion chamber at the end of each compression stroke. In view of the surprisingly good consumption figures obtained with a compression volume ratio 6 to 1, it is matter for regret that the Blackstone company

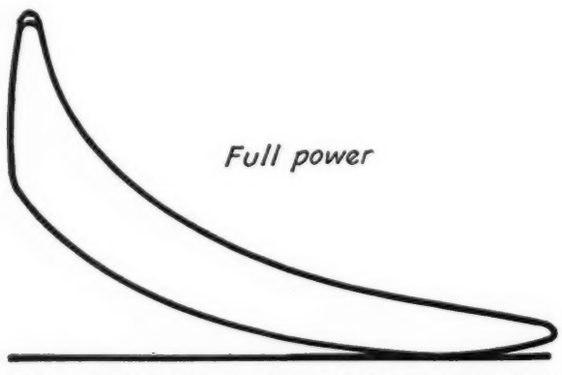


FIG. 1. INDICATOR DIAGRAM FROM BLACKSTONE ENGINE

has not developed the type to medium compression ratios beyond 6:1 up to, say, 10:1.

The next and second type comprises those engines that owe their inception to the desire to eliminate, as far as possible, the various unsatisfactory features involved in the design and construction of the Diesel engine. Of these unsatisfactory features the two most outstanding are the use of very highly compressed air for the injection of the fuel and the mechanical difficulties inherent in the use of a high compression ratio.

The objection to the use of highly compressed air for fuel injection in Diesel engines lies in the additional complexity and cost introduced into design, construction and operation, together with the obvious danger, which must be carefully guarded against, of obtaining maximum pressures much in excess of the final compression pressure. Hence arose the necessity of considering whether injection methods could be devised that would not involve the use of such highly compressed air. The main apparent difficulty in considering other schemes is the attainment of the necessary degree either of vaporization or pulverization of the

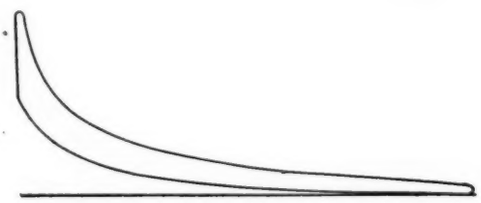


FIG. 2. INDICATOR DIAGRAM FROM CROSSLEY SOLID-INJECTION ENGINE

injected oil in order that combustion may be effected efficiently in the time available. The natural solution of the difficulty—the use of an oil pump that injects the oil at very high pressures through minute holes situated in the injector proper—has proved so far to be the best one. The solution of that difficulty then left only the problem of high compression pressures, such as are common to modern Diesel engines, to be faced. It was felt, according to the prevalent opinion, now definitely known to be wrong, that high compression pressures alone meant high thermal efficiencies, and so to maintain such efficiencies it was considered necessary to retain these high compression pressures, while at the same time minimizing, as far as possible, by careful attention to design details, the mechanical difficulties associated therewith.

A good opportunity of demonstrating the feasibility of the solid-injection method was provided by war conditions, and the principle was applied extensively in marine practice, principally, although not wholly, in Diesel or constant-pressure engines. The results obtained have so far vindicated the method that it may be said that it will become more and more universal as experimental work goes on to demonstrate the principles which must be observed in applying it. The solid-injection method, however, has not been confined to Diesel engines. For medium compression pressures the pioneers in this method appear to have been Messrs. Crossley Bros., Ltd., Manchester, where, under the direction of W. L. Webb, experimental work had been in progress for some years before the war on engines of a compression ratio of about 10 to 1. It was early realized that the most important end to be attained was the limitation of maximum pressures by purposely delaying the rate of injection toward the end of the period of injection. It is this purposely delayed injection which gives to the indicator cards of Crossley engines their characteristic dual combustion lines. Fig. 2 is a typical Crossley engine card with final compression and maximum pressures of 300 and 600 lb. per sq.in. respectively. The consumption results obtained

*Lecturer in engineering, Victoria University, Manchester, England.

to date are as good as, and bid fair to be better than, those of the high-compression Diesel engine.

The question then arises as to the reason for this result. The medium-compression solid-injection engine represents a type which, although of appreciably lower compression ratio than the Diesel engine, yet yields an efficiency of similar order. This cannot be attributed to different expansion ratios in the two types,

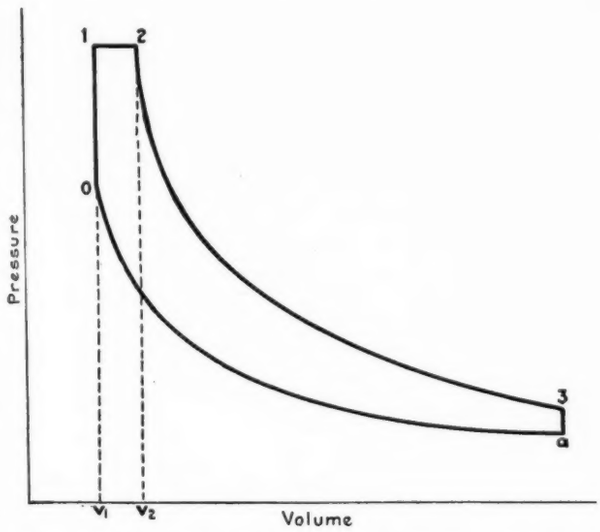


FIG. 3. IDEAL DIAGRAM FOR DUAL-COMBUSTION ENGINE

since both, as practically all modern engines with one possible exception, begin compression of the air at the same volume as that at the end of the power stroke.

A paper on "Internal-Combustion Engineering," 1914, gave a mathematical analysis of dual combustion such as occurs in Diesel engines using a light oil for pilot ignition. A mathematical slip in the latter paper, however, led to the erroneous conclusion that the introduction of constant-volume combustion into an engine hitherto operated on constant-pressure combustion, was thermodynamically disadvantageous. An independent investigation by the writer, the results of which are given in a paper on "Thermodynamic Cycles for Internal Combustion Engines," published in the *Automobile Engineer*, January, 1918, revealed the fact that constant-volume combustion is always an advantage thermodynamically. At this stage, also, the writer had occasion to study the question of combustion in high-speed petrol engines for aëro work, and the thought suggested itself that in all probability the excellent results obtained from such engines might be due to some extent to the fact that approximate dual combustion takes place naturally in these engines due to the high piston speeds. This fact prompted another investigation assuming variable specific heat conditions. This has been published recently in the "Institution of Mechanical Engineers Proceedings" (London), December, 1920, and there it is shown that maximum efficiency conditions obtain when the actual cycle approximates the theoretical cycle shown in Fig. 3, with $\rho = \frac{V_2}{V_1} = 1.2$ approximately. This result depends, of course, on the introduction of variable specific heat factors into the thermodynamical equations. It does not apply, as is well known, under constant specific heat conditions. Fig. 4 shows the efficiency curves obtained for different values of the cutoff ratio $\rho = \frac{V_2}{V_1}$ and for different compression ratios.

This furnishes one clue at least to the reason for the high efficiency of such medium-compression, solid-injection engines, but it is not the only one. Actually, the indicator diagrams of such engines, although designed to begin compression at the same volume as the expansion volume, are of the form shown in Fig. 5, where the shaded portion, less the unshaded area, represents the effective work done. It should be noticed, however, that the theoretical efficiency of the cycle should be calculated on the assumption of a constant pressure line from 4 to *b*, and it occurred to the writer to determine what the effect would be upon the efficiency for different positions of point *b;* that is, for different compression ratios. The result of the analysis is given in a paper on "A New Thermodynamic Cycle," published in *Engineering*, Vol. 109, where it was shown that the maximum efficiency condition for any thermodynamic cycle comprised between given pressure and volume limits is satisfied only when the compression ratio has some intermediate value (depending on the amount of fuel burned) between unity and the compression ratio of a Diesel engine of the same maximum pressure. Thus, if the compression

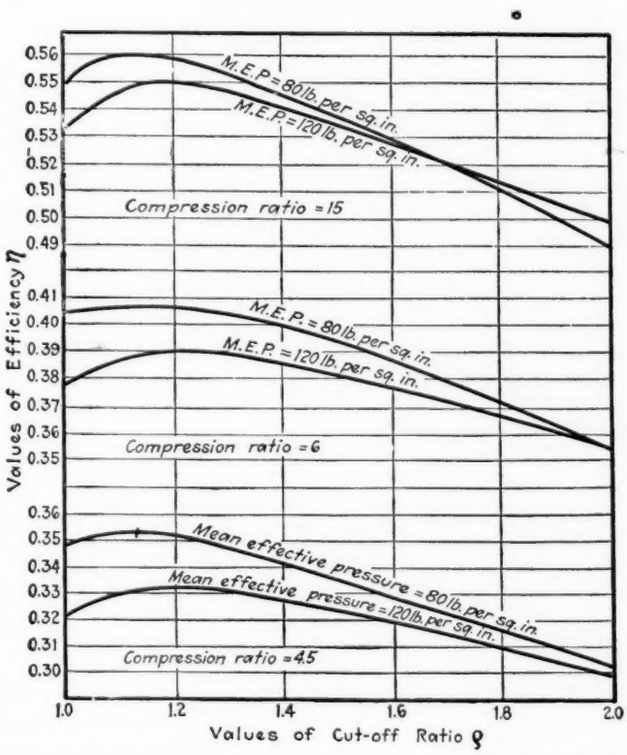


FIG. 4. EFFICIENCIES WITH VARYING CUT-OFF RATIOS

ratio of a Diesel engine were 15, its thermal efficiency would, theoretically, be increased to a maximum if beginning of compression were delayed to point *b*, Fig. 5, to give a compression ratio between 9 and 10, and combustion carried out initially at constant volume to give the same maximum pressure as before. The curve showing this relationship between efficiency and compression ratio is given in Fig. 6. The mere fact, therefore, that the compression ratio of an engine, as measured from the atmospheric point *b*, is less than its

actual compression ratio as determined by volumetric measurement of the combustion chamber, again gives dual combustion an advantage. This, together with the advantage already mentioned, accounts largely and probably wholly for the excellent results obtained from solid-injection engines operating on the dual-combustion method.

The successful application of solid injection in the Crossley cold-starting heavy oil engine depends largely

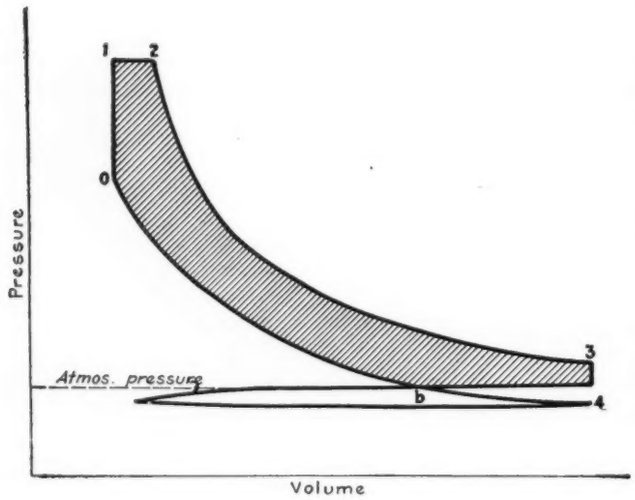


FIG. 5. ACTUAL DUAL-CYCLE DIAGRAM

on the shape of piston and combustion chamber. Experimental work demonstrated clearly that the efficient combustion of the oil depended essentially upon contact with a mass of compressed and consequently heated air. Since a spherical combustion chamber gives minimum cooling surface for a given volume, it is evident that as close a form to the spherical as possible is desirable. Since, however, there is some slight cooling effect due to the injected spray of oil, it was found that the central hot core of air was consequently displaced slightly toward the wall opposite the fuel nozzle; hence, the spheroidal form of combustion chamber as adopted by Crossley's. This form of chamber appears to have been the best so far devised to give good combustion efficiency.

An interesting article on the De La Vergne engine (which is the exception already mentioned) by E. J. Kates, bearing on this question, appeared in *Power*, Dec. 28, 1920. Here, however, the writer desires to point out that the De La Vergne company, apparently inadvertently, are working on a cycle with *b* fairly well to the left, as shown by the indicator diagram illustrated in the article mentioned, which cycle is very close indeed to the cycle that has been shown, analytically, to be the maximum efficiency one between given pressure and volume limits. There can hardly be any doubt that the good performance of the engine is due, in part at least, to that fact.

Summing up the position as represented by the Crossley and De La Vergne type engines, the following facts emerge:

1. The Crossley engine works on a dual combustion cycle in which every effort is made to introduce the maximum quantity of air; that is, *b* is kept as far to the right as possible. This is achieved by arranging the valve timing so that both the inlet and exhaust valves are open together at the end of the exhaust stroke, so that the inertia effect of the column of exhaust gases in the exhaust pipe is not checked, thus tending to draw in an increased volume of cold air into the cylinder.

2. The De La Vergne engine also works on a dual combustion cycle, in which, however, considerable throttling effect appears to occur during the suction stroke; that is, a displacement of *b* to the left, thus reducing the quantity of air available for combustion.

The advantages of method (1) are, assuming the same maximum temperature of cycle and the same combustion efficiency as for (2): (a) Increased mean effective pressure due to increased air supply; (b) increased thermal efficiency due to dual combustion; (c) increased mechanical efficiency due to increased mean effective pressure. The main disadvantage is (d) diminished thermal efficiency due to departure from the maximum efficiency cycle.

The advantages of method 2 are: (e) Increased thermal efficiency due to dual combustion; (f) increased thermal efficiency due to close approximation to maximum efficiency cycle. The disadvantages are; (g) Diminished mean effective pressure due to diminished air supply; (h) diminished mechanical efficiency due to diminished mean effective pressure.

The question that remains to be decided is, What is the compromise between the two methods? and the

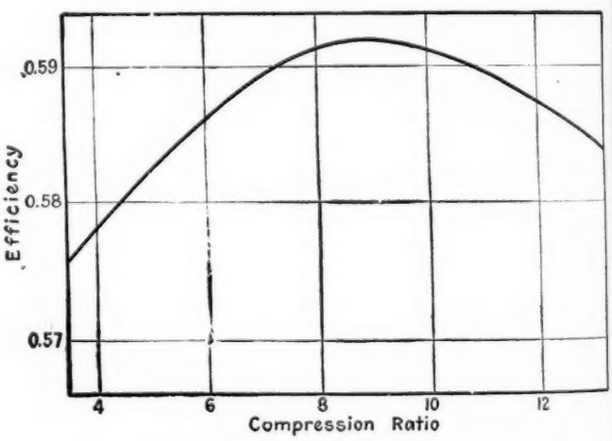


FIG. 6. EFFECT OF COMPRESSION ON ENGINE EFFICIENCY

answer to that can evidently be decided upon only along experimental lines. It appears, however, that the interaction between (c) and (d) of (1) or between (f) and (h) of (2) will lead to a best cycle with point *b* at some intermediate position between 4 and its position for maximum thermal efficiency.

Firing a boiler with green furnace walls will invariably crack the setting, hence it is necessary to dry out the brickwork properly. It is advisable to open the ashpit doors and the damper so that circulation of air will aid in drying the brickwork. Next put in a light fire of shavings, which may gradually be increased by using some wood, continuing until the walls are thoroughly dried inside and out. This will require several days, but by close observation the walls, if carefully built, can be dried out without cracking.

Heating Plan Must Be Considered

By IRA N. EVANS*

A MOVEMENT is under way for the organization of superpower systems with a view toward economizing in fuel, transportation and power generation. The proposed plan is good as far as it goes, but what is to be done with the heating? The author ventures to state that with the withdrawal from the isolated plant of the power-generating equipment, requiring skill to operate and maintain, the heating-boiler plants remaining will become even more wasteful than they have been in the past. In the scheme of operation no provisions have been made for these plants. They will require at least as much fuel as is required for the generation of power, or, stated otherwise, 50 per cent of the total power demand for a 24-hour period could be recovered from the heating fuel in the ordinary industrial plant if properly equipped. Therefore, if the power requirements are based on the present demands and the present fuel, the saving in practice of the superpower system will be less than estimated, owing to the steam needed for heating. By combining the power service with the heating in such manner as to recover the power from the heating fuel by passing the steam through a turbo-generator into the heating system, a plant could be provided that would permit maximum returns from all heating fuel.

All heating systems, particularly new installations, make successful by-product plants for power generation. The author shows how the electric generating station might profit from the byproduct current from steam. In his opinion the superpower plan will not realize its best possibilities unless simultaneous consideration is given to heating demands.

Fig. 1 shows a diagram of the equipment necessary to separately generate steam for power and heating. Hot water under forced circulation is the heating medium and live-steam heaters are employed. It is a diagram of an actual installation. Power is generated separately in boilers having a total of 30,000 sq.ft. of heating surface. The same capacity in equipment would have to be utilized in the central station if power were purchased. A cooling tower is shown as an alternate for a natural lake. In this plant 30,000 sq.ft. in boiler-heating surface is provided for power generating and 50,000 sq.ft. of boilers to carry the maximum heating load.

To carry a 5,000-kw. load at 2 lb. of coal per kilowatt-hour will require 10,000 lb. of coal per hour. Of this only 1,250 lb. is converted into electrical energy in the average condensing plant. The remaining 8,750 lb. of coal is lost in the steam-generation process or is passed to the cooling tower or lake, being lost in both cases.

Of the 50,000 sq.ft. in heating boilers, all will be idle in summer, say for four months, and 20,000 sq.ft. will be idle 50 per cent of the winter, in periods of lighter heating load. The amount of coal required for heating in this plant, and it would be practically the same for any other system, is 16,500 lb. per hour in zero weather and 7,000 lb. in 65-deg. weather, with approximately 11,000 lb. as the average.

Fig. 2 shows the power and heating plants combined, with 30,000 sq.ft. in boilers eliminated, together with the corresponding operating expense, upkeep, auxiliary machinery, buildings, etc. In this plan the boilers are used for both purposes. All steam passes through the turbines, with vacuum control, so that the steam rate may be varied from 35 lb. per kw.-hr. at no vacuum to 17 lb. at 28 in. of vacuum, thus providing a variable amount of steam for heating with a constant power-load recovery. At times when no heating is required, a 28-in. vacuum may be carried and power generated at the minimum steam rate. At the same time the temperature of the water in the heating system varies with the vacuum, providing a range from 200 deg. at no vacuum to 90 deg. at a 22-in. vacuum.

In practice this arrangement would permit full range in the vacuum, and with proper equipment the full power and heating loads may be carried or any portion of either without stopping the machine or opening the relief valve. As the vacuum is regulated in connection with an outdoor thermometer, any change in outside temperature is met with a corresponding variation in the temperature of the heating medium long before a thermostat placed in the room could operate. Due to the building mass and the contents, it is sometimes hours after the outside weather changes before a room thermostat would be affected. In this way more even regulation is effected with far less fluctuation in the steam demand.

In the combination plan 20,000 sq.ft. in boiler-heating surface is idle in summer, owing to no heating load and 10,000 sq.ft. would be idle during 25 per cent of the winter months. The accompanying table gives a comparative summary of the two plans.

The investment in equipment is to all purposes the same excepting that there is a credit to plan 2 for 30,000 sq.ft. in boilers. The figures given are subject to variation, but the general saving is basic and does not depend on the particular types of apparatus used or manipulation of the equipment. The relations hold for all combined heating and power plants. All that is necessary is sufficient capacity, say 300 kw. as a minimum, to make condensing operation pay.

Recovery of power from the heating steam should appeal particularly to the central station, as a public-service company controlling the generation of electrical energy can utilize the recovered power at all hours, day or night. The industrial plant can use it only about 14 hours out of the 24, due to shutting down nights, although the heating has to be maintained continuously. A subsidiary company of the central station might furnish the generating equipment and the attendance. All heating steam would be passed through the turbine to a hot-water heating system. The current received from the heating fuel and metered back to the central-station mains would form the basis of the rebate to the large consumer.

*Consulting Engineer, 253 East Lawn Ave., Detroit, Michigan.

Another plan would be for the consumer to furnish all fuel, tend his boilers and the heating system. The generating equipment could be leased and form a substation of the public-service company. Breakdown service could be furnished from the main station and the plant temporarily heated with live steam. The arrangement would pay about 90 per cent gross on the cost of the generating equipment, and the maximum economy could be obtained from all fuel.

If current is sold at 2c. per kw.-hr. and it requires 2 lb. of coal to generate a kilowatt-hour, the selling price per ton of coal of 2,000 lb. is: $\frac{2,000}{2} \times 0.02 = \$20$. At 1.2c., the present lowest rate obtainable where the customer furnishes his own transformers and pays for the maximum demand whether the current is utilized or not, the selling price per ton of coal is $\frac{2,000}{2} \times 0.012 = \$12$. Heating is sold at $1.50 per 1,000 lb. of steam for the first 100,000 lb. and $1.25 per 1,000 lb. for all steam in excess of this amount, with 10 per cent off the bill for cash. Assume an evaporation of 8 lb. of water per pound of coal and $1.15 as the average net rate per 1,000 lb. of steam, in that case the selling rate per ton of coal would be $\frac{2,000 \times 8}{1,000} \times \$1.15 = \$18.40$. This is about the same price per ton as for current at the 2c. rate, although the electric plant operates all the year round as against eight months for the heating, and the investment and maintenance of distributing lines for steam heating is much greater than for the generating plant.

In the combination plant assume a minimum steam rate for generation of current of 20 lb. of steam per kilowatt-hour, and a maximum rate of 35 lb. per kw.-hr. in zero weather, the former being full condensing and the latter, noncondensing operation. The average rate on the combined plant would be about 140 per cent of the minimum, or 28 lb. per kw.-hr. Taking, as before, 8 lb. as the evaporation and the average steam rate as 28 lb., the kilowatt-hours recovered per ton of coal during the heating season would be $\frac{2,000 \times 8}{28} = 571.4$ kw.-hr. At the 2c. rate the revenue per ton of coal would be $571.4 \times 0.02 = \$11.43$ and at the 1.2c. rate, $571.4 \times 0.012 = \$6.86$. As 90 per cent of the heat in the exhaust steam is available for heating, the revenue per ton of coal from this source, at $1.15 per 1,000 lb., would be $0.9 \times \$18.40 = \$16.56$. In the following the selling price per ton for separate operation may be compared with combined operation requiring 37.5 per cent less boiler capacity.

1. Current separate, rate 2c., $20 per ton of fuel.
2. Current separate, rate 1.2c. $12 per ton of fuel.

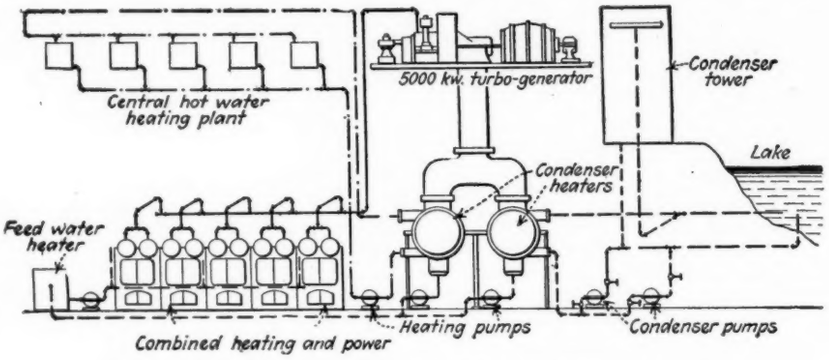


FIG. 2. COMBINED POWER AND HEATING INSTALLATIONS

3. Heating separate, $1.15 per 1,000 lb., $18.40 per ton of fuel.
4. Combined heating and power, rate 2c., $11.43 + (0.9 × $18.40) = $27.99.
5. Combined heating and power, rate 1.2c., $6.86 + (0.9 × $18.40) = $23.42.

This is an increase of 40 per cent in gross revenue on the high rate and nearly 100 per cent on the low rate. It means that central heating will pay universally and solve the heating question as affecting the superpower program. The plant arranged with cooling towers may be operated the year around. If the heating requirements for zero weather are known, the installed turbo-generator capacity should be of a value that the heat in the exhaust steam equals the heating-system demand. The minimum steam required for heating and power will be the rate for this generator capacity at full vacuum. It may be assumed that if 33⅓ per cent live steam is added to the balanced power demand at minimum, full vacuum rates, the total will equal the average steam required for power and heating combined for the season. This arrangement allows the central heating plant to be operated the year round with an economy only slightly less than for the main station when the high-tension lines are taken into consideration. It would increase the capacity for power generation at no expense whatever for the boiler installation, and waste in heating would tend to be corrected, owing to the sale of the power recovered.

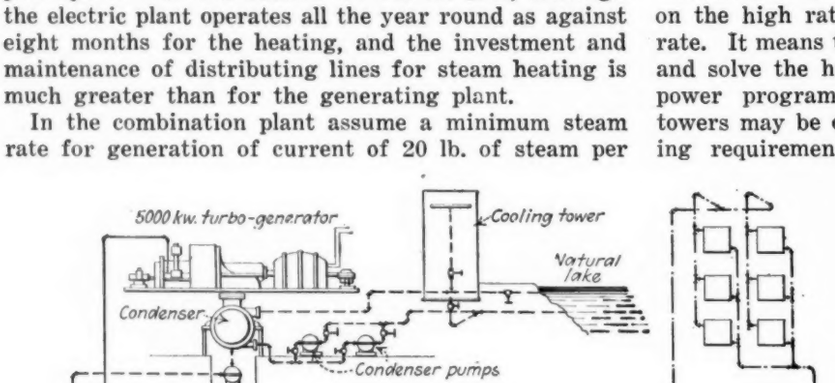


FIG. 1. SEPARATE POWER AND HEATING INSTALLATIONS

COMBINATION VS. INDIVIDUAL OPERATION FOR POWER AND HEATING

Saving in boiler capacity:	
Plan 1—Boilers installed, sq.ft. heating surface	80,000
Plan 2—Boilers installed, sq.ft. heating surface	50,000
Saving in boiler capacity, per cent	37.5
Saving in coal:	
Plan 1—Coal per hour, lb. = 10,000 + 11,000	21,000
Plan 2—Average coal per hour, lb	11,000
Saving in coal per hour, per cent (10,000 ÷ 21,000	47.6

Industrial Power-Plant Data

Census Figures from Twenty-six States Covering Primary Power in Manufacturing Establishments

THE Census of Manufactures has now reported many additional figures regarding power plants at manufacturing establishments in the United States in 1919, covering the power used and the cost of fuel and power in mine, quarry and well-drilling operations.

Table I shows by states the primary horsepower installed at manufacturing establishments in 1919, the

TABLE I. POWER INSTALLATIONS AT MANUFACTURING ESTABLISHMENTS

Preliminary Partial Reports from Census of Manufactures, 1919

State	Primary Horsepower Installed	Percentage Increase in Horsepower 1914–1919	Increase in Percentage of Wage Earners 1914–1919
Alaska	18,676	369.8	112.2
Arizona	103,958	90.1	23.6
Colorado	194,634	19.5	29.2
Delaware	85,150	32.2	31.1
District of Columbia	33,079	33.5	49.6
Hawaii	64,295	53.3	68.9
Iowa	253,945	32.9	27.8
Idaho	72,254	43.6	56.2
Kansas	232,879	30.0	47.1
Maine	566,705	16.3	8.8
Mississippi	200,703	7.7	22.1
Montana	169,056	84.4	25.3
Nebraska	125,814	39.5	45.2
Nevada	13,874	-26.0	-14.7
New Hampshire	311,722	-9.4	4.8
New Mexico	17,260	38.4	51.9
North Dakota	17,791	26.5	36.5
Oklahoma	141,832	45.8	69.3
Porto Rico	67,226	97.7*	2.6*
Rhode Island	318,673	18.1	23.1
South Dakota	22,191	35.9	68.5
Tennessee	615,725	114.6	28.0
Utah	92,236	54.9	35.5
Vermont	185,107	6.4	2.5
Wyoming	17,624	76.2	120.1

*10 year increases.

percentage increase in this power installation during the five preceding years and the percentage increase in wage earners in the same industries during the same period. It should be noted that out of the 26 states

TABLE II. PRIMARY HORSEPOWER INSTALLED IN MANUFACTURINT ESTABLISHMENTS IN CERTAIN CITIES

Preliminary Partial Reports from Census of Manufactures, 1919

City	Primary Horsepower Installed	Percentage Increase in Horsepower 1914–1919	Increase in Percentage of Wage Earners 1914–1919
Phoenix, Ariz	2,844	59.9	93.0
Tucson, Ariz	1,636	-17.2	96.5
Los Angeles, Cal	94,876	46.7	98.5
Boulder, Col	1,150	153.9	83.3
Colorado Springs, Col	1,220	14.6	32.7
Denver, Col	41,413	56.0	50.4
Greeley, Col	602	-3.4	4.7
Pueblo, Col	5,882	56.2	104.4
Trinidad, Col	861	-1.0	133.9
Wilmington, Del	51,290	31.6	42.3
Boise, Idaho	1,598	51.8	64.7
Pocatello, Idaho	3,289	-14.1	109.6
Anaconda, Mont	1,063	38.7	8.4
Billings, Mont	1,602	14.7	74.2
Butte, Mont	2,017	64.5	41.1
Great Falls, Mont	3,345	55.9	63.9
Helena, Mont	658	-4.8	8.9
Missoula, Mont	1,580	131.0	103.1
Reno, Nev	1,329	-14.6	-3.6
Albuquerque, N. M	1,744	-6.8	51.5
Fargo, N. D	1,627	27.6	4.8
Grand Forks, N. D	1,175	28.7	46.1
Minot, N. D	962	- *	- *
Aberdeen, S. D	4,750	89.3	58.3
Sioux Falls, S. D	1,338	52.0	84.7
Salt Lake City, Utah	15,796	23.8	29.0
Barre, Vt	8,019	34.2	-19.8
Burlington, Vt	9,409	17.6	36.6
Rutland, Vt	4,096	29.7	10.4
Caspar, Wyo	1,396	- *	- *
Cheyenne, Wyo	4,380	199.0	70.6

*No data for 1914.

thus far reported 15 show greater increase in number of wage earners than in power installations. This would indicate that the ratio of man-power to horsepower is increasing were it not for the fact that the power here summarized is only the primary horsepower of the manufacturing establishments themselves. The power purchased or "rented" from central stations is not included. If this were added in, it is probable that in every state one would find greater percentage increase in the power consumption than in the number of wage earners employed, for this has been the tendency for over 50 years past and there is no reason to believe that the tendency would not continue during this past decade.

The second tabulation shows similar data for municipalities. These figures indicate that the totals for states are in general quite typical of commercial power use in manufacturing establishments. These commercial totals are, of course, included in the corresponding state figures of Table I.

The mining and quarrying census is taken but once in ten years. The figures of Table III are, therefore,

TABLE III. HORSEPOWER INSTALLATION AND FUEL COSTS FOR MINING, QUARRYING AND WELL DRILLING.

Partial Preliminary Summary of Data from Census of Mines and Quarries, 1919

State	Primary Horsepower Installed	Per Cent Increase in Horsepower 1909–1919	Increase in Number Wage Earners 1909–1919	Cost for Fuel and Power 1919	Per Cent Increase in Fuel and Power Costs 1909–1919
Alabama	145,775	58.6	13.0	3,080,283	193.7
Arizona	166,091	251.4	26.6	5,377,525	-4.0
Arkansas	21,915	55.6	-19.9	441,261	217.5
Colorado	116,351	17.8	-20.1	2,706,480	38.4
Connecticut	8,520	35.3	-62.7	120,374	67.4
Florida	44,969	6.1	-10.7	1,687,696	38.0
Georgia	13,006	21.6	-34.3	355,884	142.6
Idaho	30,942	17.7	-34.5	513,778	24.5
Illinois	318,321	41.3	9.7	5,784,829	336.3
Indiana	129,703	36.5	18.1	2,012,706	264.7
Iowa	32,171	37.2	-30.9	748,844	23.8
Kansas	133,984	100.1	8.8	4,305,575	1,506.8
Kentucky	148,893	179.9	125.4	2,522,749	1,054.6
Louisiana	86,132	919.9	673.6	2,812,864	286.9
Maine	6,252	-23.2	-51.0	122,692	44.9
Maryland	18,234	0.6	-18.5	308,766	196.4
Massachusetts	12,498	-16.9	-45.8	263,345	71.8
Michigan	337,587	23.3	-19.6	8,444,697	101.4
Minnesota	144,219	-5.0	2.7	4,681,952	131.3
Missouri	100,160	-8.7	-39.4	2,035,913	-8.3
Montana	143,793	-17.5	-15.8	2,979,928	-17.9
Nevada	50,785	89.1	-5.9	1,751,266	33.5
New Hampshire	4,351	15.4	-48.1	64,980	19.4
New Jersey	33,901	87.8	-27.8	719,938	125.5
New Mexico	59,876	273.2	31.8	1,361,210	570.3
New York	91,339	-10.2	-43.2	1,402,245	139.6
North Carolina	5,039	-16.9	-26.4	220,731	113.6
North Dakota	2,037	0.6	34.2	37,694	193.7
Ohio	337,611	14.5	-0.1	4,131,068	362.8
Oregon	5,764	-28.6	-13.3	128,404	32.9
Rhode Island	3,000	27.7	-37.7	55,075	104.0
South Carolina	4,656	-33.6	-48.8	150,440	27.6
South Dakota	11,844	-24.3	-56.3	284,019	-32.5
Tennessee	56,685	64.2	-10.9	1,259,983	95.2
Texas	129,138	303.5	208.3	6,189,559	2,321.4
Utah	86,131	82.4	-0.9	2,019,110	88.0
Vermont	28,099	5.7	-60.5	425,348	15.8
Virginia	56,491	63.1	-7.3	1,216,894	151.2
Washington	39,998	92.8	-18.9	1947,330	285.3
Wisconsin	26,780	7.7	-36.6	872,265	100.1
Wyoming	62,757	106.9	24.2	1,072,787	185.2
	3,255,778			$75,620,498	

a comparison of 1919 with 1909. It is shown here that about 3¼ million horsepower are installed at mine, quarry or well-drilling operations of the 41 states thus far reported. The percentage increase in power varies widely, as will be seen from the second column of this table. Ten of the 41 states show decreases in power installations but it is probable that in most if not every one of these ten the reduction in the "installed" power has been brought about by use of power purchased from central stations. The reduction shown in

this column for ten states is in the aggregate very small; it represents only about 50,000 hp. altogether.

Percentage increases in wage earners appear mainly as negative figures, for 29 of the 41 states report a reduction in the number of wage earners employed in 1919 compared with 1909. Only five of the states show a greater percentage increase in wage earners than in horsepower installation. Thus it would appear that the mechanicalization of mine and quarry operations has proceeded conspicuously during the last decade.

That fuel and power are a considerable factor in mine and quarry costs is evident from the total of over $75,000,000 expended for these items during 1919. In almost every case the cost has increased materially, as shown by the figures in the last column of this table. This increase in cost, however, does not necessarily mean an increase in quantity of fuel and power of corresponding magnitude. As everyone knows, the cost per unit of power or per unit of fuel during 1919 was in almost every part of the country distinctly above the unit cost ten years before. Only four of the Western States show a decrease in cost for fuel and power. Apparently this may be attributed in at least three cases to a reduction in activity.

Victor High-Pressure Damper Regulator

An hydraulically operated damper regulator suitable for boiler pressures up to 250 lb. has recently been developed. The operating water enters the regulator through the inlet *A* and passes to the pilot valve, then to the bottom of the control cylinder through the port *D*. It also passes to the control cylinder on top of the piston through the pipe *E* into the hollow piston stem and into the control cylinder through the holes *F*.

The pilot-valve stem *I* is of spool form with the upper head passing over the port *D*, which, when above the port, permits the water to pass into the bottom of the cylinder, and when below the port, permits the water to escape from the bottom of the cylinder into the outlet *C*.

The area of the top of this piston is reduced by an equal amount to the cross-sectional area of the piston stem, thus the area of the bottom of the piston is larger. Therefore, when pressure is admitted to the bottom of the cylinder the piston is forced up, and when the pressure is permitted to escape from the bottom of the cylinder the constant pressure forces it down.

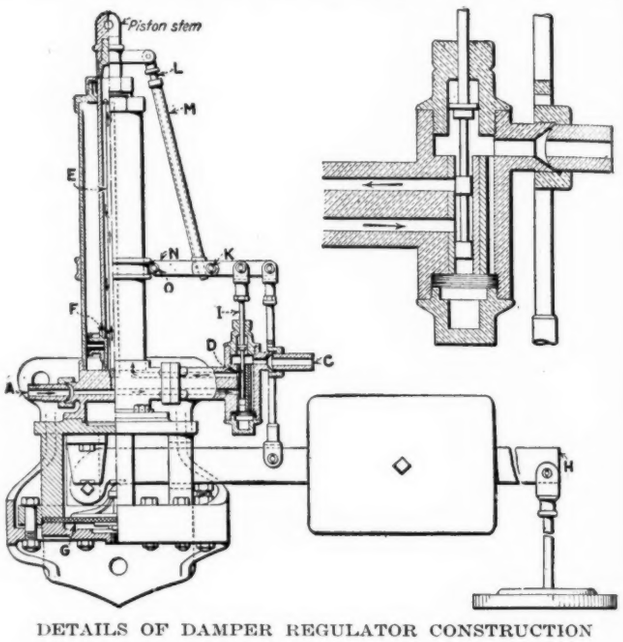
When the steam pressure under the diaphragm *G* is sufficient to raise the lever *H*, the pilot-valve stem *I* is pulled up by the short lever swinging on the axis *K*, and this permits the water to pass into the bottom of the control cylinder and force the piston up.

As the piston moves up, the rod *L* is pulled upward in the sleeve *M*, which is rigidly attached to the lever *N*, swinging on the axis *O*. As the point where rod *L* is attached to the piston stem travels in a straight line, the sleeve *M* must swing outward, which depresses the axis *K* on the lever *N*, and pushes the pilot-valve stem *I* down so that the upper head of the stem covers the port *D* and shuts off the water supply to the bottom of the control cylinder, which checks the upward travel of the piston.

When the steam pressure falls, the lever *H* lowers and pulls the pilot-valve stem *I* down so that its upper head is below the port *D*. This permits the water in the bottom of the control cylinder to escape into the outlet *C*, which allows the constant pressure on top of the piston to force the piston down.

As the piston moves down, the rod *L* slides into the sleeve *M*, which must swing inward, which raises the axis *K* and pulls the pilot-valve stem *I* up so that the upper head of the stem covers the port *D* and shuts off the water discharge from the bottom of the cylinder, checking the downward travel of the piston.

This compensating attachment acts as an intermediary medium to counteract the movement transmitted to the pilot valve by the steam pressure under the



DETAILS OF DAMPER REGULATOR CONSTRUCTION

diaphragm, which balances the position of the damper on intermediate pressure changes and permits the damper to be fully opened or closed only on extreme boiler-pressure variations. This regulator is manufactured by the Atlas Valve Co., 282 South Street, Newark, N. J.

Wire Gage by Memory

The B. & S. wire gage has some easily memorized properties, from which an approximate table can be carried in the mind. The items to remember as approximately true are as follows: (1) A No. 10 wire has a diameter of $\frac{1}{10}$ in. and a resistance of 1 ohm per 1,000 ft.; (2) increasing the wire size 3 numbers doubles the circular mils and halves the resistance, or decreasing the size 3 numbers halves the circular mils and doubles the resistance.

For example, to find the size and resistance per 1,000 ft. of a No. 1 cable: A No. 10 wire has a diameter of $\frac{1}{10}$ in. or 100 mils, and therefore an area of 100×100 or 10,000 circ.mils approximately. Increasing the size by steps of three numbers, No. 7 would be 20,000, No. 4, 40,000, and No. 1, 80,000 circ.mils. The table shows that this is approximately correct. Resistance per 1,000 ft. for the conductors is, for No. 10, 1 ohm, No. 7, $\frac{1}{2}$ ohm, No. 4, $\frac{1}{4}$ ohm, and No. 1, $\frac{1}{8}$ ohm or 0.125 ohm, which agrees with the table. For sizes that do not happen to fall on the third number from the starting point the results may be obtained approximately. Note that the diameter does not increase in the same proportion as the area, but doubles every six instead of every three gage sizes.

Simplified Chemical Method of Detecting Surface Condenser Leakage

By W. E. CALDWELL

IN MANY plants where the condenser circulating-water supply contains a large proportion of chlorides accompanied by other impurities, it is advisable to to test the condensate periodically to detect the presence of chlorides. While those usually found in condensing-water supplies are not a great source of trouble in boilers, their presence gives an indication that the troublesome scale-forming or corrosive elements present in the raw circulating water are also entering the feed-water system through leakage in the condensers. The detection of chlorides is rendered very simple by chemical means. Although the water may contain magnesium chloride in addition to sodium chloride, the latter usually predominates, and since it is stable at high temperatures and very soluble, alone it is harmless. Magnesium chloride, however, is unstable at boiler temperatures and is likely to decompose under certain conditions, causing corrosion if proper treatment is not applied to prevent it.

The usual method of detecting chlorides quantitatively, known as the silver-nitrate method, requires in addition to the solutions, a graduated glass burette with stand together with a flask and pipette, and is the standard method of volumetric analysis used in the laboratory. In a pump room or boiler room, however, the standard method is rather tedious and the apparatus subject to breakage. A simpler method herein described, may be used, and while not possessing the same degree of accuracy as the standard method, it is sufficient for the purpose.

In order to estimate the amount of leakage of raw water into your condenser, make up your solutions as explained in this article. If it takes 800 drops of the nitrate to turn the raw water faintly red and 4 drops to do the same with the condensate, the leakage of raw water is 4 divided by 800, or 0.5 per cent.

The required glassware and solutions are as follows: Two dropping bottles (Barnes) with rubber pipette stoppers (empty recorder-ink bottles and droppers, thoroughly cleaned, will suffice); one 50-c.c. graduated glass cylinder; one 100-c.c. glass beaker and thin glass stirring rod; 250 c.c. of silver-nitrate solution, containing 9.6 grams of pure crystallized silver nitrate per liter; 250 c.c. of potassium-chromate solution, saturated. One of the dropping bottles is filled with potassium-chromate solution, known as the indicator and so labeled, while the other is filled with silver-nitrate solution.

The method of procedure is as follows: The sample of condensate to be tested is poured into the glass graduate until level with the 50-c.c. mark and emptied into the glass beaker. Two or three drops of the indicator are added and the sample is stirred continuously with the glass rod, while the silver nitrate is added cautiously. The dropper should be held in a vertical position and the drops of silver nitrate counted as they fall, stopping with the first indication of a change in color to a faint blood-red tinge. It is difficult for the beginner to determine when sufficient nitrate has been added, since only a perceptible change in color indicates the end point, but with a little experience the slightest change in color is easily detected. The titrating or testing should be conducted where the light is good and with a white dish or white paper under the beaker, since the white background renders the delicate change in color more pronounced. The number of drops of nitrate used is recorded and is an index of the quantity of leakage, as explained in the assumed cases following. If the first drop turns the color, there is practically no leakage.

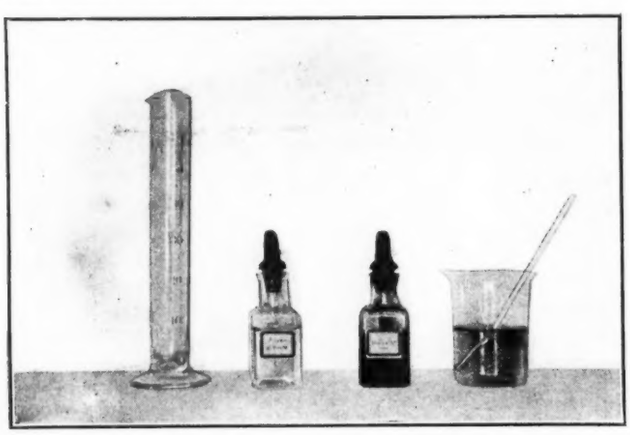
The raw circulating water must now be tested in the same manner, but only 0.5 c.c. of it is taken for the test and diluted with pure water to make a 50-c.c. sample. The sample thus prepared is a 1 per cent solution of raw water, and may be accurately prepared as follows: Fill the graduated cylinder to the 45-c.c. mark with pure clean rain water or clean melted snow and add sufficient raw circulating water to bring the level to the 50-c.c. mark. Mix thoroughly, discard all but 5 c.c. of the mixture then add sufficient pure rain water to restore the level to the 50-c.c. mark. The mixed water now contains 1 per cent of raw water. Pour this into the beaker and test as before. Suppose the raw water thus diluted required 8 drops of silver-nitrate solution to effect the change in color. Since there was but 0.5 c.c. of the raw water tested, or a 1 per cent solution, owing to the dilution, it becomes necessary to multiply the number of drops by 100 to determine the number required by a standard 50-c.c. sample. In the case cited it would be 800 drops. The necessity for diluting the raw water for the test is evident from the large number of drops required for a 50-c.c. sample of undiluted raw water.

Assuming that the 50-c.c. sample of condensate required 4 drops of silver-nitrate solution to produce the change in color, this would be equivalent to $\frac{4}{800}$ leakage or 0.5 per cent. If the chloride content of the raw water, or the number of drops of nitrate required to change the color, has been determined to be fairly constant over a given length of time, it is unnecessary to test the circulating water further, once this relation has been established. With little or no variation in the chloride content of the raw water, it is obvious that each drop of silver nitrate required by the condensate represents a certain leakage. In the assumed case 4 drops were equivalent to 0.5 per cent leakage, or one drop would be equal to 0.125 per cent leakage. By using a 40-c.c. sample of condensate in subsequent tests, each drop of nitrate required would be equal to 0.1 per cent leakage.

As the water rate of a unit exhausting into a condenser may be estimated fairly closely, the quantity of raw water entering the system may be easily computed

when the condenser leakage is known. If an analysis of the raw water is available, the leakage tests may be used to compute the quantity of scale-forming, or corrosive ingredients, entering the boilers, and employed as an index of amount of feed-water treatment necessary.

It is sometimes necessary to test the concentration of the water in the boiler, for it has been established that the precipitation of scale-forming salts increases rapidly above a certain percentage content of solids, and the boiler should be cleaned out when the concentration reaches that value. The water from the boilers may be tested by the same method, provided it is neutral or but slightly alkaline. However, if it is either acid or strongly alkaline in reaction, it must be neutralized before testing, which necessitates additional solutions and apparatus. If the water is known to be neutral, the test is conducted in the same manner as the test of the condensate, with the exception that the sample is diluted. The graduate is filled to the 45-c.c. mark with pure rain water, to which sufficient water from the



APPARATUS FOR DETECTING CONDENSER LEAKAGE BY THE SIMPLIFIELD SILVER-NITRATE METHOD

boiler is then added to bring the level to the 50-c.c. mark, and thoroughly mixed. The number of drops of silver nitrate required to effect the change in color must be multiplied by 10 in order to refer the result to a 50-c.c. undiluated sample. For example, if the diluted sample of boiler water required 14 drops of nitrate to change the color, a 50-c.c. undiluted sample would require 140 drops. If the concentration of the raw water is known, that of the boiler water may be obtained by multiplying that of the raw water by the ratio $\frac{140}{800}$. Ordinarily, in testing boiler water it is advisable to use a stronger silver solution and observe precautions that are beyond the scope of this article.

There is little value in knowing the absolute quantity of chlorides present either in the condensate or the raw water, but if desired, it can be determined with a fair degree of accuracy from the number of drops of silver nitrate used. If droppers are selected with a bore of not less than $\frac{1}{16}$ in. at the dropping end and an external diameter at that end no greater than $\frac{1}{8}$ in.., each drop of silver nitrate will be equivalent to about 0.0001 gram of chlorine in the sample tested, since the drops average about 0.05 c.c. each. With a dropper as described and the samples assumed in the foregoing example, the raw water would contain about 0.08 gram of chlorine in a 50-c.c. sample, the condensate would contain about 0.0004 gram and the boiler water 0.014 gram in a 50-c.c. sample. To express this in terms of grains of chlorine per U.S. gallon, multiply the number of grams in 50 c.c. by 1,166, which gives 93.2 for the raw water, 0.466 for the condensate and 16.3 for the boiler water. If it is desired to express the values as grains of sodium chloride per U.S. gallon multiply the figures by 1.65.

In general, the chlorine content of raw waters may vary from a faint trace in some river waters to more than a thousand grains per U.S. gallon in sea water. In any raw water in which the presence of salt is indicated by the taste, the silver-nitrate method may be used to detect leakage while the unit is in operation. Where the raw water contains a large amount of chlorides in solution, such as sea water, it is advantageous to use a stronger solution of silver nitrate, containing 48 grams per liter, each drop corresponding to 0.0005 gram of chlorine in the sample tested.

Placing a Storage Battery In and Out of Commission

By L. W. Webb

Manufacturers usually furnish specific instructions for assembling and charging cells of their make. However, a general description may be of assistance when these are not available. When a battery is first received, it must be unpacked very carefully and all parts thoroughly cleaned. If the electrolyte is shipped in the cells, care must be used to see that none is spilled out. Inspect the cells carefully to see that none is cracked or leaking and if any such are found, set them aside immediately and never attempt to use them even temporarily. If the elements and separators are sent separately to be installed in jars, they should be examined carefully and all cracked ones discarded.

When installing the elements in the jars, use extreme care and never force anything into place. Place the cells side by side in the proper position and connect the terminals together either by bolt connectors or by burning; always scrape all surfaces clean and bright before connecting up and line up the cells carefully so that no strains will be thrown on the straps that might react on the elements. Always be sure the polarities are correct before making connections; that is, positive terminals to negative terminals. If the electrolyte has not been shipped in the cells, it should now be poured in until the plates are covered by about $\frac{3}{4}$ in. or 1 in. If the cells contain wooden separators, they should be allowed to stand for at least 12 hours before starting the initial charge, so that the acid will have plenty of time to soak into the separators and the active material of the plates. Be very sure that no acid is spilled over the jars or on the sides, and examine all cells carefully for leaks or undue heating. The gravity will be found to have dropped considerably after the period of soaking due to the acid absorbed by the plates.

Initial Charge

The charging current must in all cases be direct current and never alternating current. Connect the positive terminal of the battery to the positive terminal of the charging circuit, also negative to negative, with a suitable resistance in the charging circuit so that current can be regulated. Before starting the initial charge, be sure the charging voltage is above the full-charge voltage of the battery, allowing at least 2.6 volts per cell in series. For instance, if there are

50 cells in series, the charging voltage should be at least $50 \times 2.6 = 130$ volts. Care should also be taken that all the resistance is cut in before the charging switch is closed. Close the switch and regulate the resistance until normal current is flowing through the battery. Hold this charging current constant by gradually cutting out the charging resistance until the voltage and specific gravity stop rising. Keep careful watch to see that the cells are not heating up, and if this occurs, reduce the charging current or cut it off entirely and allow the battery to cool down before again turning on the current. It will usually require about 50 hours for the initial charge when cells were not sent assembled with acid in them. During the charge, watch for leaky jars, heating or excessive gassing of individual cells, and be sure that all connections are tight.

All exposed metal parts or connections that are not lead-covered should be thoroughly greased with petrolatum, vaseline or good-quality acid-proof paint to prevent oxidization. After the cells are almost fully charged, they will begin to gas freely, and current should then be cut down to a lower finishing rate and held there until the voltage and gravity stop rising. After the charge is complete, wipe all jars, covers, etc.; clean off all acid to prevent grounds. It will usually be found that the battery will not come up to its full capacity until it has been charged and discharged two or three times.

Batteries Should Be Periodically Overcharged

At least once a month the battery should be given an overcharge at a low rate, as this tends to reduce all the sulphate that has collected on the plates that may not already have been reduced by the normal charging current. This also causes the active material to be worked more evenly throughout the whole battery and tends to prevent low cells. At the end of the charge the specific gravity of all the cells should be the same, as specified by the manufacturers, varying with the different types from 1.220 to 1.300. The lower figures are usually for stationary-type batteries having Planté elements and the higher figures for pasted types for motor vehicles, trucks, etc. If, during charge, the electrolyte falls for any reason below the level of $\frac{3}{4}$ in. above the top of the plates, it should be brought up by adding only pure distilled water, unless drop in level was caused by leakage, slopping over, etc., in which case electrolyte of the same specific gravity should be used. In all cases, whenever manufacturer's directions are available, follow them as closely as possible.

Placing Out of Commission

If a battery is to remain idle for any length of time (a week or more), it should be fully charged before standing. If it continues idle, a freshening charge should be given about every two weeks at low-current rates and continued until the cells are gassing freely, to prevent any chance of sulphating. Idle batteries lose part of their charge due to local losses in the cells which the freshening charges may not entirely eliminate, and if the battery is to be left idle for extended periods, it should be put out of commission to save undue loss of material or cost of freshening charges and necessary attendance. There are two general methods of placing a battery out of commission:

1. Charge the battery until the specific gravity of the electrolyte of every cell has remained constant over a period of one hour, taking particular care to see that there are no low cells; then disconnect the cells and lift the elements from the jars, separate the positive and negative elements and remove the separators. If possible, place the elements in a rack and play a gentle stream of water over them to wash off all the electrolyte; then allow them to dry. A careful watch should be kept to see that the negative plates do not heat up while drying; if they are found to be heating up or steaming, they should be rinsed, dipped or sprinkled with water until the temperature rise ceases. If the active material on the negative plates seems swoolen or extends beyond the ribs of the supporting frame, it should be pressed back into place before the plate begins to dry. The following is a convenient method of doing this: Cut smooth boards for spacers, of a thickness equal to the distance between the plates, then pile up the elements, with a wooden spacer between each pair of plates, and put the group under pressure. In large batteries, where the elements are in single plates, they should be placed on a smooth board and rolled with a rubber roller until the active material is well rolled in. A smooth wooden roller will answer, but not so well as rubber. Sulphate shows itself as a whitish deposit on the elements and should be removed by scrubbing before the plates become dry, using special care not to scrub hard enough to take off the active material. After the negative elements are dry, they should be immersed in electrolyte for about 6 hours and then allowed to dry; they are then ready to be put away. Be careful in washing or draining the positive elements, as the active material is very soft and liable to be washed away. After drying they are ready to put away. Always store positive and negative elements separate from each other, a good way being to fill up one half of the jars with positive and the other half with negative plates, or to hang them on separate racks. If rubber separators were used in the battery, they can be washed off, dried and put away. Wood separators will not stand much handling, and if considered worth keeping, they should be immersed in water or weak electrolyte and never be allowed to dry. If the battery is to remain out of commission for long, it is usually cheaper and better to throw the wooden separators away and purchase new ones when it is desired to place the battery back in commission.

2. With large cells for stationary use, usually of the Planté type, and mounted in glass jars or lead-lined tanks, the following method of placing out of commission is generally used:

Fully charge the battery and allow a good overcharge to reduce all sulphate and bring up the low cells; then immediately discharge to about 1.76 volts per cell. All electrolyte should then be drawn off, the cells filled with pure distilled water and again discharged until the voltage almost reaches zero. It will be necessary to short-circuit the cells to bring the discharge voltage as low as possible, and as no sulphate can form when discharging them in water, no injury is done to the plates. They should then be taken out, the elements washed, pressed or rolled as previously explained, and replaced in the jars, either dry or in water as desired. In this condition they can stand indefinitely without deterioration. Cells of this type often have no sheet rubber or wood separators; but when they do, the same instructions as herein given will apply.

In putting these back in commission, the same instructions should be followed as with a new battery.

Convenient Tables for Steam Flow in Pipes*

By V. F. DAVIS†

IN ENGINEERING practice tables are almost invariably more desirable than charts. Tables are more easily understood, quicker and more accurate. Many charts dealing with the flow of steam through pipes have been published in recent years, but they all have their objections. Some of them are so intricate that engineers soon forget how to use them if not in constant practice, and much study is required to master them each time. Some of the tables are inaccurate or incomplete, while others are so graduated and constructed as to make them impractical. Hence the writer has decided to compute carefully and compile a set of accurate and dependable steam-flow tables. Two of the tables accompany this article.

If steam pressures and the demand for steam were always constant, reducing valves would not be necessary. Under such ideal conditions we would merely install a pipe line small enough to create the desired pressure drop when supplying the required weight of steam. In other words, the loss of pressure would be effected by the frictional resistance offered by the pipe through which the steam passed.

In actual proctice, however, absolutely constant steam pressure and constant demand for steam seldom if ever exist. Variation of initial pressure means variation of final pressure, and variation of both initial pressure and demand creates a variation of steam velocity through the pipe. If flow were controlled by pipe size alone, this velocity might often exceed the practical limit and would then be harmful.

The volume and velocity of steam flowing through any pipe line are both increased as the pressure drop or difference between the initial and final pressure is increased. This drop in pressure is, of course, always due to friction. Up to the present time no one has scientifically determined the practical limits for steam velocities in various pipe sizes. The usual practice today among designing engineers is to use rules of thumb and then exercise the best judgment, basing that judgment upon the initial and final pressures and the service under consideration. Judgment is always necessary, to be sure, but it should not be overworked when definite figures are available.

The principal objections to the flow of steam at too high velocity are: (1) The noise; (2) wiredrawing effect of the steam in passing through fittings and valves; (3) damage to pipe fittings, bends, valves, etc., if the steam contains moisture or if it is highly superheated; (4) loss of energy due to friction.

The last objection, "loss due to friction," is not a serious one because friction always generates heat, which in turn tends to dry or superheat the steam. Besides, its influence is usually so small that it may well be neglected. For most practical purposes it is safe to limit the pressure drop to ten pounds for high-pressure work and to one pound for low-pressure work. Of course the nature of the service and the initial and final pressures must be considered for each problem.

An old and common practice among engineers is to use pipes of such size that the mean velocity of steam in them does not exceed 6,000 ft. per min. for stationary work or 8,000 ft. per min. for marine work. These rules, however, give unnecessarily large and costly pipe for high-pressure steam. There is a more scientific method of pipe-size determination—the method that should always be used. In the tables accompanying this article the capacities of various pipe sizes are given. By using the tables, it becomes a simple matter to determine the size of pipe required for any given service. Upon determining the size of pipe, the size of the reducing valve becomes known simultaneously because in all cases the size of the reducing valve should be the same as that of the initial-pressure pipe.

How to Use the Tables

Table I gives the weight of steam that will flow per minute through straight pipe lines 100 ft. long under various initial pressures. The pressure drop in every case is exactly one pound. In other words, if the initial pressure is 100 lb. the final pressure is 99 lb.; if the initial pressure is 50 lb., the final is 49 lb., etc. These tables were computed from Babcock's formula, the derivation of which is given in "Steam" (thirty-fifth edition), published by the Babcock & Wilcox Company.

TABLE I. STEAM FLOW IN POUNDS PER MINUTE FOR 100-FT. PIPE AND 1-POUND PRESSURE DROP

Initial Steam Pressure, Pounds per Square Inch, Gage	Nominal Pipe Size, Inches: ¼	1	1¼	1½	2	2½	3	4	5	6	8	10	12	15	Initial Steam Pressure, Pounds per Square Inch, Gage
	Weight of Steam Delivered per Minute for 100-Ft. Pipe and 1-Pound Pressure Drop														
1	0.459	0.913	2.01	3.12	6.32	10.42	19.89	40.34	74.64	122.5	255.0	465.3	746.8	1,394	1
5	0.506	1.04	2.24	3.48	7.05	11.62	21.27	44.94	83.18	136.5	284.1	518.5	832.1	1,553	5
10	0.563	1.14	2.49	3.88	7.86	12.95	23.66	50.10	92.73	152.1	316.0	578.0	927.6	1,732	10
20	0.664	1.34	2.94	4.56	9.24	15.23	27.89	58.94	109.1	179.0	372.6	680.0	1,091	2,037	20
30	0.749	1.51	3.32	5.15	10.43	17.20	31.48	66.52	123.1	202.0	429.5	767.4	1,231	2,299	30
40	0.824	1.66	3.65	5.67	11.48	18.93	34.66	73.23	135.5	222.4	462.9	844.9	1,355	2,531	40
50	0.892	1.79	3.95	6.13	12.42	20.48	37.50	79.22	146.6	240.6	500.8	913.9	1,466	2,738	50
60	0.955	1.92	4.23	6.56	13.30	21.93	40.15	84.84	157.0	257.6	536.3	978.7	1,570	2,932	60
70	1.013	2.04	4.49	6.97	14.12	23.28	42.62	90.06	166.6	273.5	569.3	1,039	1,667	3,113	70
80	1.068	2.15	4.73	7.34	14.88	24.54	44.92	94.93	175.6	288.3	600.0	1,095	1,757	3,281	80
90	1.121	2.26	4.96	7.71	15.61	25.75	47.13	99.60	184.3	302.5	629.6	1,149	1,843	3,450	90
100	1.170	2.36	5.18	8.05	16.32	26.89	49.23	104.0	192.5	315.9	657.5	1,199	1,925	3,595	100
120	1.264	2.54	5.60	8.69	17.61	29.04	53.16	112.3	207.8	341.4	710.0	1,295	2,079	3,882	120
150	1.391	2.80	6.16	9.56	19.38	31.96	58.51	123.6	228.8	375.4	781.5	1,426	2,288	4,273	150
200	1.579	3.18	7.00	10.85	22.00	36.28	66.42	140.3	259.1	426.3	885.2	1,617	2,598	4,851	200
250	1.748	3.52	7.74	12.01	24.35	40.11	73.52	155.3	287.5	471.8	982.0	1,792	2,876	5,370	250

This well-known formula is:

$$W = 87\sqrt{\frac{p\,D\,d_1^{5}}{\left(1+\frac{3.6}{d_1}\right)L}}$$

Where

W = Weight of steam flowing through the pipe in pounds per minute;

p = The difference in pressure between the two ends of the pipe in pounds per square inch;

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†Engineer with the Atlas Valve Co.

D = Density of the steam, or weight (in pounds) of one cubic foot of steam at the average of the initial and final pressures;

d_1 = Actual internal diameter of standard pipe in inches;

L = Length of pipe in feet.

The following examples show how to use Table I:

Example 1—What size reducing valve and initial-pressure pipe are required to supply 25 lb. of steam per minute, with one pound loss of pressure through 100 ft. of pipe? The initial pressure is 90 lb. per square inch.

Answer—In Table I, corresponding with 90 lb. pressure we find 25.75 lb. of steam per minute under 2½-in. pipe. A 2½-in. reducing valve and initial-pressure pipe will therefore be required.

Example 2—What size reduced-pressure pipe line is required to carry 25 lb. of steam per minute with one pound pressure loss through 100 ft. of pipe where the reduced pressure is 20 lb. per sq. in.?

Answer—In Table I, corresponding with 20 lb. pressure, we find 27.89 lb. of steam per minute under 3-in. pipe. A 3-in. pipe line will therefore be required.

Where pressure drops are more than one pound and where pipe line lengths are more or less than 100 ft., Table II is used in conjunction with Table I. Table II takes care of all pipe lengths varying from 25 ft. to 1,000 ft. as well as pressure drops varying from one pound to 25 lb.

Table II is calculated from this formula:

$$F = \sqrt{\frac{100 \times p}{L}}$$

where F is the factor to be used and p and L are the same as in Babcock's formula.

To apply Table II, simply multiply the quantities given in Table I by the proper factor from Table II. The following are some typical examples showing how these tables are used:

Example 3—What size reduced-pressure pipe line is required to carry 250 lb. of steam per minute, where the pipe is 150 ft. long, the drop in pressure is one pound and the reduced pressure is 10 lb.?

Answer—In Table II under 150 ft. and on a line with one pound pressure drop we find the factor 0.816. Looking in Table I, on a line with 10-lb. pressure and under 8-in. pipe, we find 316 lb. Multiplying 316 by the factor 0.816 gives 258 lb. per min. as the capacity of an 8-in. pipe under the given conditions. An 8-in. pipe will therefore be ample.

Example 4—What should be the size of the reducing valve and initial pressure pipe, if the pipe is 200 ft. long, the drop in pressure is 10 lb., the initial pressure 120 lb. and 250 lb. of steam per minute is required?

Answer—In Table II under 200 ft. and on a line with 10-lb. pressure drop we find the factor 2.23. Dividing 250 lb. by 2.23 we get 112 lb. as the corresponding weight of steam delivered per minute for 100 ft. of pipe and one pound pressure drop. Looking in Table I, on a line with 120 lb. pressure we find a delivery of 112.3 lb. per min. under 4-in. pipe. A 4-in. reducing valve is therefore required.

Example 5—A 3-in. line 150 ft. long is supplying a reducing valve with 56.6 lb. of steam per minute. The initial pressure is 100 lb. The drop in pressure is 2 lb. What would be the pressure drop if the supply were increased to 85 lb. per minute?

Answer—In Table I, under 3-in. pipe and on a line with 100-lb. pressure we find the weight of steam delivered for 100 ft. of pipe and one pound pressure drop to be 49.23. Then, dividing the quantity desired (85) by 49.23, we get the factor 1.72. Now, from Table II, under 150 ft. we find the factor 1.63 on a line with a 4-lb. drop and the factor 1.82 on a line with a 5-lb. drop. As 1.72 is more than the factor 1.63 and less than the factor 1.82, the drop in pressure will be between 4 and 5 pounds.

It must be remembered in using Babcock's formula as well as in using these tables, that "hairbreadth accuracy" is not of much value because pipes are made only in certain sizes. Thus if one applies Babcock's formula and laboriously finds the internal diameter in a given problem to be 2.63795427003 in., it is evident that much valuable time has been wasted in performing a problem of division. Standard pipes are not made in that size. The actual internal diameter of a 2½-in. pipe is 2.469 in., the size that should be used. Selecting a slightly smaller size simply increases the pressure drop, a condition that is usually permissible. It is a simple matter to check back and determine the exact pressure drop with the smaller size of pipe and decide whether the smaller size is practical. The smaller the valve and the smaller the pipe, the greater the saving in first cost.

TABLE II. FACTORS TO BE APPLIED TO TABLE I FOR VARIOUS LENGTHS AND PRESSURE DROPS

Where the length of pipe is not 100 ft. or the pressure drop is not one pound, use Table II to get a factor for the given length and pressure drop. Multiply the amounts shown in Table I by this factor to get the actual amount.

Pressure Drop Pounds per Square Inch	Length of Pipe in Feet — FACTOR													Pressure Drop 1,000 Pounds per Square Inch
	25	50	75	100	125	150	175	200	250	300	400	500	750	1,000	
1	2.00	1.41	1.15	1.00	0.894	0.816	0.756	0.707	0.632	0.577	0.500	0.447	0.364	0.316	1
2	2.82	2.00	1.63	1.41	1.26	1.15	1.07	1.00	0.894	0.816	0.707	0.632	0.575	0.447	2
3	3.46	2.44	2.00	1.73	1.54	1.41	1.31	1.22	1.09	1.00	0.866	0.774	0.632	0.547	3
4	4.00	2.82	2.30	2.00	1.78	1.63	1.51	1.41	1.26	1.15	1.00	0.894	0.730	0.632	4
5	4.47	3.16	2.58	2.23	2.00	1.82	1.69	1.58	1.41	1.29	1.11	1.00	0.816	0.707	5
10	6.32	4.47	3.65	3.16	2.82	2.58	2.39	2.23	2.00	1.82	1.58	1.41	1.15	1.00	10
15	7.74	5.47	4.47	3.87	3.46	3.16	2.92	2.73	2.44	2.23	1.93	1.73	1.41	1.22	15
20	8.94	6.32	5.16	4.47	4.00	3.65	3.38	3.16	2.82	2.58	2.23	2.00	1.63	1.41	20
25	10.00	7.07	5.77	5.00	4.47	4.08	3.77	3.50	3.16	2.88	2.50	2.23	1.82	1.58	25

Locating Trouble on Elevator Equipment

By William Zepernick

It is essential, when clearing trouble from electrical equipment, to obtain as much information as possible concerning the conditions. The information should be used only for the purpose of obtaining as many viewpoints of the trouble as possible and not for the purpose of investigation. Too many times has the investigator been misled by doing so. It is also essential that nothing be taken for granted, for it is a simple matter to be misled, particularly when the mind is occupied with a solution for electrical trouble. This point is clearly brought out in the following narrative:

Upon completion of the installation of an electric elevator to be driven by a 220-volt 60-cycle motor, an attempt was made to operate it under power. The motor would not turn over but remained idle, producing the characteristic hum associated with such a condition. Test lamps made up of two 110-volt lamps were

borrowed from a local electrician, and a test was made to determine if there was an open phase on the line. The line tested clear, but no results were obtained from the motor. Without further consideration the rotor was removed on the assumption that there was trouble in the winding, which caused the difficulty experienced. When the rotor had been replaced after it had been tested and no trouble found, the same results were obtained.

At this time an investigation was made of the test lamps, and it was found that instead of being connected in series they were connected in multiple. As the sockets had been taped together as one unit, this could not be determined by observation. One might say that unscrewing one bulb should have caused the other bulb to be open-circuited and go out if the lamps were in series, but therein lies the fallacy of one person relying upon another in the case of trouble hunting. This condition, of course, immediately solved the problem. The lamps, being connected in multiple, lighted to full brilliancy on 110 volts, indicating that the supposedly 220-volt motor was in reality connected to a 110-volt system. The torque developed by the 220-volt motor connected to a 110-volt line was insufficient to turn the machine over.

Gradeca Combustion Control

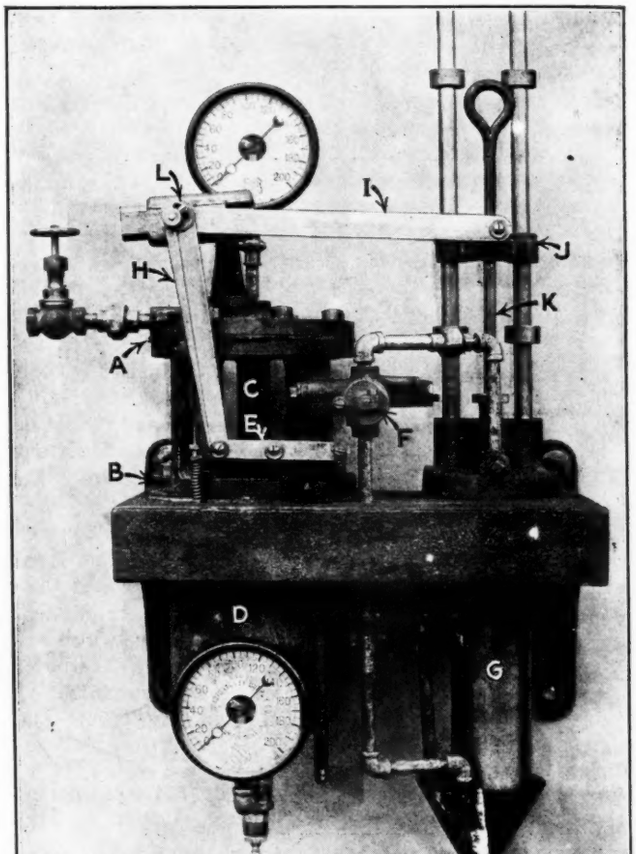
Graduated decremental operation characterizes the combustion-control apparatus illustrated herewith. The device consists primarily of two large-diameter diaphragms *A* and *B*, with a vertical strut *C* between. Diaphragm *A* is under boiler pressure on its upper side, and diaphragm *B* forms the upper end of a pneumatic balancing chamber *D* and receives a suitable air pressure on its lower side. Gages are provided to indicate the pressure on each diaphragm. The volume of air in the balance chamber is so proportioned that the full depression of the diaphragm *B* increases the air pressure less than one-quarter of a pound.

A downward travel of the strut rod *C*, due to increased steam pressure on the diaphragm *A* is imparted to the floating lever *E*, one end of which operates the hydraulic valves *F* for controlling the admission and exhaust of water for operating the single-acting plunger in the cylinder *G*; the other end is connected by means of the vertical link *H* and the horizontal lever *I* to a crosshead *J* on the piston rod *K*. The crosshead eyebolt is for connection to the damper and the stoker gear.

A downward movement of the crosshead *J* takes place when an increased steam pressure on the diaphragm *A* causes a movement of the lever *E* sufficient to open the controlling valves *F* and allows water under pressure to flow into the cylinder *G*. As the crosshead descends, a compensating effect is imparted through the lever *I* and link *H* to the floating lever *E*, which tends to move the valve to the zero or closed position, thus preventing the admission or escape of water pressure from the cylinder *G* and so holds the piston rod in the new position, which it occupies until another change of steam pressure occurs. A further increase in steam pressure results in further amounts of downward travel, variations in the scale of graduations being obtained by changing the angle of the slide *L* which carries the connected ends of the link *H* and also the lever *I*.

This design of regulator causes the damper to move through a greater distance at the beginning of a pressmachine progresses, so that furnace conditions are consure rise and gradually slow down as the stroke of the trolled with the least possible amount of disturbance, yet with sufficient effect for the purpose. With a dropping pressure the action is reversed and the fire is gradually increased in intensity.

A convenient adjustment is provided which compensates for any slight change in air pressure and also



GENERAL DETAILS OF REGULATOR

enables the damper to be moved to any part of the stroke for operating purposes and then returned to its original position for any prearranged pressure.

This apparatus has been developed by J. M. Wilson, 1036 Arlington Ave., S.W., Canton, Ohio.

A 350-hp. Still combined oil-steam engine has been erected and tested at the Scott's Shipbuilding and Engineering Co.'s plant at Greenock, Scotland. It is reported that the fuel consumption was lower than in a straight Diesel oil engine of like power. While this engine will probably find favor in Europe, as long as oil prices remain low ots complicated mechanism will not appeal to American engineers.

The Ocean Steamship Co., of Liverpool, has on order what is expected will be the largest motor-ship in existence. She is to have a deadweight carrying capacity of 15,000 tons. The vessel will be fitted with Burmeister Wain Diesel engines which, with a combined horsepower of 6,400, will drive her twin screws.

EDITORIALS

A Model Industrial Power Plant

IN THIS ISSUE the leading article describes the new power plant of the Hershey Chocolate Company at Hershey, Pennsylvania. Many of the old timers in power station operation will recognize the vast change in power-plant design and no doubt will feel that a plant like Hershey is a pleasant place to dwell in. Although the outside architectural features of the plant might be somewhat out of place around industries where the surroundings are not so pleasing as they are at Hershey, nevertheless the layout of the station to obtain good lighting and make for clean and efficient operation can be well applied to all industrial plants. In the average industrial power plant where overhead coal bunkers are installed, with the flues located over the boilers, there is small oportunity for good natural lighting. In the Hershey plant the flue has been located in the basement of the boiler room, which has not only simplified the construction and reduced the load on the building structure, but has resulted in a reduction in building height and made possible excellent natural lighting not only over the boilers, but also in the firing aisle.

In the modern power plant using steam turbines it has become general practice to locate all auxiliary equipment in the turbine room or turbine-room basement. There are many advantages in doing this, since it centers the control of the equipment for the operating force and also places it where it will be exposed to a minimum of dust and dirt. Where natural draft is used, the boiler-room basement is an empty space. If the flues can be located here, it may result in considerable reduction in building-construction cost as well as a more convenient layout of the plant.

Using weighing larries to distribute the coal from the bunker to the stoker hoppers is not new in large power-station operation, but in plants the size of the one under discussion their use has been limited. However, a look at the firing aisle shows that the usual array of coal pipes and spreaders is missing. Much can be said in favor of the former arrangement, since it not only eliminates the coal pipes and spreaders which obstruct lighting in the firing aisle and interferes with working around the boilers, but it also provides a convenient means of weighing the coal to each boiler.

There is a marked difference found when comparing the water rates obtained in this station with those obtained in large stations built for the purpose of generating power only. In the large stations where advantage can be taken of every refinement in power-plant design, with turbine operating on high-pressure high-temperature steam expanding to a high degree of vacuum, a water rate of between ten and eleven pounds per kilowatt-hour is obtained. In the plant under discussion a water rate of over sixteen pounds per kilowatt-hour is the best obtained. But in the former steam temperatures of six hundred degrees and higher are used, expanding to less than one inch absolute pressure, where in the latter the steam temperature is considerably less than five hundred degrees and the vacuum two inches absolute. However, the Hershey plant is designed to meet a particular industrial-load condition requiring large volumes of low-pressure steam at various pressures. In this respect, for clean-cut design, arrangement of equipment and provisions to obtain operating records it is undoubtedly a model of what an industrial power station can be made.

The Patent Office Is Still Neglected

DISCUSSION of the troubles and difficulties of the United States Patent Office has seemed to lapse for the last few months, so that some may have thought that the situation had mended and that the poverty-stricken condition of this very important department of the Government had been corrected. Such is not the case, according to a statement recently issued by the Patent Committee of the American Engineering Council, of which Edwin J. Prindle, of New York City, is chairman.

It is pointed out that the previous Congress did not take the necessary action to reorganize the Patent Office, and that the situation therefore remains as serious as it was before.

A bill that aims to correct this situation is the Lampert Patent Office Bill H.R. 7079, which provides that the salaries of examiners and the fees for patents shall be correspondingly increased, so that the Patent Office may remain, as in the past, a more than self-supporting institution. It has received the unanimous approval of the Patent Committee of the House of Representatives and has been made special by the Rules Committee. The following excerpts from the statement of the American Engineering Council's Patent Committee indicates the very pressing need for the immediate passage of the bill:

> The examining force of the Patent Office has been and is being so weakened by resignations of a large proportion of its best men, due to the extreme meagerness of the salaries paid, that the work has fallen behind and has deteriorated in quality. The working staff has been diluted through replacement of seasoned employees by those who are so deficient in education as to be even unable to pass the entrance examinations.
>
> The trained men of the Patent Office, of whom so much is expected, were paid, when their salaries were fixed in 1848, $2,500 a year, the same compensation as members of the House of Representatives and United States District Judges. While, however, these other salaries have been raised three hundred per cent in the intervening seventy years, the examiners during that period have been raised only ten per cent. Since competent examiners command large compensation in the practice of patent law outside of the Patent Office, many of them who would otherwise have preferred to remain in the Patent Office have resigned until now there is but a skeleton of the old efficient organization left.

The legislators at Washington are doubtless very busy, and it is always expected that Governmental

action will be distressingly slow, but in this case it appears to have been delayed even longer than usual. The Engineers' Committee has no axe to grind, and has no political plums in sight, so that its report deserves consideration.

Water-Power Progress and Prospects

THE results of the first year's operation of the Federal Power Commission are an evidence of progress and a promise for the future that is most gratifying and encouraging. During this year nearly fifteen million horsepower has been under consideration in the cases filed with the commission. This development, far in excess of the entire present installation of the United States, will, of course, not all be realized even in the future, but it represents in a single year five times the activity that was evidenced during fifteen preceding years. It is, as the commission says, "a clear indication of the need for the legislation and the extent to which power development had been delayed by the lack of satisfactory Federal laws."

Power is essential to all industries. It is very appropriate, therefore, that the Federal Government should utilize every resource at its command for the development of the natural resources that contribute to power supplies on every scale. Small installations of less than one hundred horsepower are thus receiving the attention of the commission. And the three million horsepower project on the Colorado River, which has been proposed by the Southern California Edison Co., comes in for its deserved share of attention and encouragement.

The law is yet far from perfect, but it has accomplished much, thanks to the diligence and efficiency of those who have been charged with its administration. These officers should receive the thanks and the encouragement of all. Furthermore, they should receive support of the engineering profession in the effort to secure that additional authority and provision for the personnel of the commission which would do much to expedite and simplify administrative function. Over two million horsepower has made progress to the point of preliminary permit or license, but there remains much work to be done and a staff not altogether adequate to the task.

A New Oil-Engine Cycle

IN THE SEARCH for some means of eliminating the air-injection feature of the Diesel engine while still maintaining its high thermal efficiency, many manufacturers have brought out a decided variety of new designs. A study of these new engines convinces the observer that many are arrived at in a most haphazard way. On the other hand, a few engines do display a fuel economy equal to the air-injection Diesel, and to most engineers the reasons for this high efficiency are unknown.

The engineers as a body have been educated to believe that the engine efficiency depends on the compression ratio alone which theory is contradicted by the low compression and high efficiency of the so-called solid-injection oil engine. On another page Dr. Walker discusses some of the theoretical aspects of the solid-injection engine which he terms a dual-cycle engine. He points out that the high efficiency of this engine is in the main to be attributed to the combustion at constant volume followed by combustion at constant pressure, and efficiency secured by various cutoff ratios. Of extreme interest is his contention that one factor assisting the securing of a high efficiency is the throttling of the suction air, giving a fairly high compression ratio with a low compression pressure.

In units of moderate powers the solid-injection, or dual-cycle, engine has a promising future. At the present time in the United States three manufacturers are building solid-injection engines, operating on an approximate dual cycle, while several semi-Diesel builders are producing engines that are fast approaching this cycle.

A Proposed Solution for Muscle Shoals

LAST March Congress refused the appropriation necessary for the completion of the Wilson Dam at Muscle Shoals; it having previously turned down the proposition for the creation of a Government nitrate corporation to supply nitrates in the form of fertilizer. Accordingly, Secretary of War Weeks announced that he would seek no further appropriations from Congress, but would entertain proposals from any private interests on terms that would be equitable to the Government. As a war measure the whole project had cost several times what it normally would, and many doubted its commercial value in peace times.

Now along comes Henry Ford with a proposal to take a one hundred years' lease on the dam and nitrate plant, to pay the Government six per cent return on the estimated cost and to amortize the investment during the life of the lease. Moreover, as a promise to the farmers to furnish cheap fertilizer, he would limit his profits to eight per cent.

Obviously, the next move is up to Congress, and it will be interesting to follow the influence that will be brought to bear on that body, both from those who are likely to regard the Ford proposition as competition and, on the other hand, from the farmers who are anxious for cheap fertilizer. The proposal is apparently made in good faith, and both from the standpoint of the government and that of the agricultural interests far outweighs any that has been made heretofore. Moreover, the prestige of Henry Ford and his organization should furnish ample assurance of the faithful carrying out of the terms.

Whether Mr. Ford's proposition is accepted or some counter proposals from other parties, it will have afforded the Government an opportunity to offset a portion of its war expenditures, and in this case Congress would do well to put aside political expediency for practical commercial considerations.

Quite frequently statements are made to the effect that a given device will improve efficiency a given percentage. The resulting saving is then computed, based on full-load operation for twenty-four-hour operation for three hundred to three hundred and sixty-five days a year. The impression gained is liable to be misleading. Periods of idleness or stand-by are common to most equipment, and the average load is usually but a fraction of full load. A utilization factor, similar in most respects to load factor, must be taken into consideration in determining the possible saving from any efficiency-improving expenditure.

CORRESPONDENCE

Steam-Jet Ash-Conveyor Performance

The recent discussion on the steam-jet conveyor must have been of considerable interest to prospective users as well as those that are already using this type of apparatus. There must be several thousand installations of this type in use so that the subject should have wide appeal.

Little has appeared in print on the steam-jet ash conveyor, and what there is seems to be offered from the viewpoint of manufacturer rather than from that of the user. There is comparatively little real practical information available as to how best to operate a steam jet, how much steam is used, etc. Recently, I examined about 100 reports on steam-jet ash conveyors, submitted by their purchasers. Not one of these was of any real value to the engineer. Many were favorable, some were unfavorable; many more were non-committal, all were vague and incomplete. Man-hours saved were sometimes given; in no case was the steam consumption per operation or per ton of ash moved stated, nor were the tonnage and the distance involved.

Information of this sort is badly needed in the interest of the steam ash conveyor. Reliable and economical performance make good talking points; convincing operating data clinch the sale. It is cold-blooded advantages that weigh in the balance these days, and the sales engineer that has the actual operating data can tip the scales in favor of his product.

Just what is the field of the steam jet? It has its field, beyond which it is not indicated as the solution. It may even have a field where it is supreme. But what are its limitations? Quantity and the character of the ash handled are important factors affecting the decision in favor of any special type. Distance over which the ash is to be moved and the method of final disposal are basic factors. The space available under the furnace is another important factor and one that has resulted in many steam-jet installations in existing plants. Other factors are the cost of labor, plant personnel, location of plant, etc.

When choosing apparatus, the purchaser wants to know the relative advantages and disadvantages of each type and the relative cost of operation of each type. It is not enough to know the man-hours saved as compared with manual labor. The criterion is the relative performance of machines, not of man. It rarely pays to do things by hand any more. Yet man-hours saved, upon which the steam-jet ash-conveyor manufacturers lay such stress, is not all-important, because the man or men who handle the ashes may do other work beside. The final decision is based on the cost of handling a ton of ashes. What is that cost and how does that cost vary during the life of the conveyor? What is the life? Answers to these questions for all types of conveyors would be a really valuable contribution to ash-disposal engineering.

Manual labor for ash handling has no place in a plant where the coal is handled, measured and burned mechanically, where the soot is removed mechanically and the log of performance is kept mechanically. The problem is not whether mechanical ash conveyors ought to be used, but what type is the best for the job.

As David Moffat Myers has so aptly said, "The man times the machine equals the result." The steam-jet ash conveyor is particularly subject to abuse through ignorance and thoughtlessness of the men using it. The manufacturers of this type of apparatus might well take more active steps in order to mitigate the evils that result.

It is common to find the suction hole for the ash left uncovered with steam turned on, while the laborer leisurely rakes the ash pile toward the suction inlet. The writer has seen this done to such an extent that stopping it cut the steam consumption in half or, rather, the time for blowing ash in half. If ash must be brought to the suction inlet, steam should be turned off while doing it. Men should be made to understand that to leave steam on an open suction inlet is to waste steam. Often the ash is too large and should be broken up.

On the basis that one ton of coal contains 10 per cent of ash, and that one pound of coal produces ten pounds of steam, how many pounds of steam are used per ton of coal for moving the ash? What does the steam cost per 1,000 lb.? Between what limits do these range? One usually is told that the steam required for handling ashes is too small to meter and too cheap to bother about. Perhaps it is. In any case there is often a small economy to be derived from blowing out the ashes at the noon hour or at the close of the working period, when there tends to be excess steam available. When steam that would otherwise escape at the blowoff is used for moving ashes, it is fair enough to consider that steam cheap.

There are a number of similar economies possible in using the steam-jet ash conveyor. Were they given publicity, they would be of value to hundreds of engineers as well as to those that sponsor this type of apparatus. May we not have them?

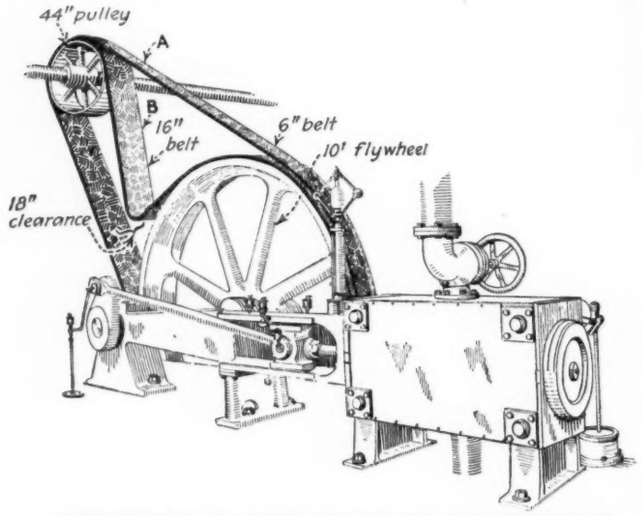
M. A. WALKER.

Chicago, Ill.

Running with a Slack Belt

A peculiar belt arrangement was recently seen at the plant of the Tide Water Oil Co. This was used in connection with a 100-hp. Corliss engine that drove the lineshaft from which the pumps used in pumping wax through the wax filter presses were belted.

The engine flywheel was 10 ft. in diameter, and the driven pulley 44 in. The belt was 16 in. wide, and



A 16-IN BELT RUN WITH BUT 18 IN. BETWEEN THE SLACK AND TIGHT SIDES

the peculiar feature about it was that instead of being run tight as shown by the belt *A*, it was run slack as shown by *B*, the least distance between the two belt faces being but 18 in. A 6-in. keeper belt *A* ran on top of the 18-in. belt. This apparently has given no trouble from slipping.

The engine has a record of 11 months and 15 days continuous running. At the time it was seen, it had been running over seven months without shutting down.

Jersey City, N. J. W. H. HATCH.

Saving by Proper Ash-Handling Equipment

In the issue of May 24, page 861, I read the communication by C. F. Herington referring to the article of Hubert E. Collins on page 581 in the April 12 issue, on the subject of saving by proper ash-handling equipment. I am prompted to answer this from a desire to enlighten Mr. Herington, as well as to correct any false impression that may result from this treatment of Mr. Collins' article.

Mr. Herington claims that Mr. Collins is wrong and attempts to prove his case by a series of questions and generalities. With the ashes deposited in bins, making it possible to load easily either a truck or wagon and cart them away, the cost of transporting ashes from the plant to some more or less distant locality is in many cases eliminated so far as the owner of the plant is concerned. In many instances this is also converted into an item of return, because the cinders are frequently bought, where they are so easily loaded, to be carried away. Mr. Collins, therefore, is fully justified in treating this item as he has.

Mr. Herington states that a few years ago he made an investigation of the steam ejector system for handling ashes for one of the stationary plants of the New York Central Railroad. Possibly, upon further investigation he would now find that there have been great strides made in this method of ash conveying. I would suggest that he look up the New York Central plants at Coalburg and Minerva, Ohio, which are in his immediate vicinity, and also a number of installations in Akron, Ohio, among which he will find the Pennsylvania Railroad, as well as the Akron, Canton & Youngstown.

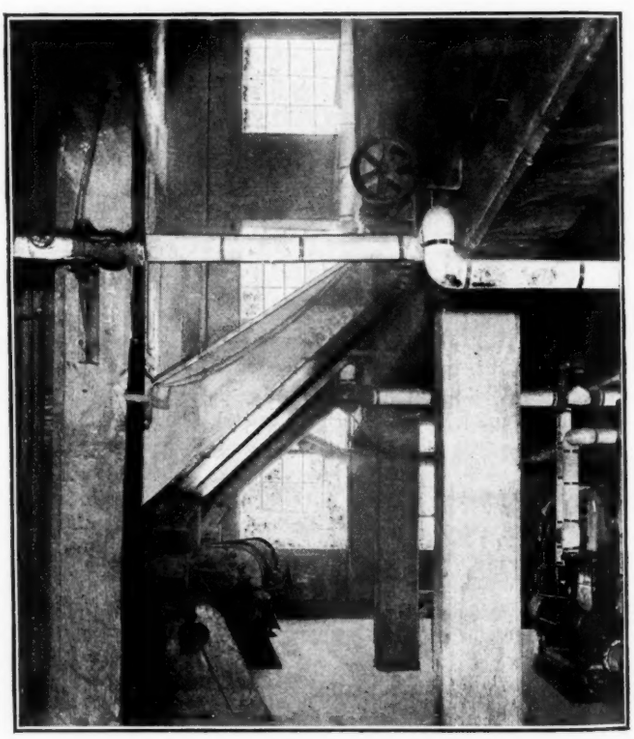
He speaks of the cost of the steam to transfer ashes. It is true that it takes a certain number of pounds of steam to move 100 lb. of ashes a distance of 100 ft., but a thorough investigation will demonstrate that this cost as opposed to the labor cost involved is materially less. C. F. ZIMMERMANN.

Chicago, Ill.

Concrete Coal Bunkers and Spouts

I happened to visit a boiler room recently and was impressed with the design of the coal bunker and spouts between it and the stoker hoppers. The concrete coal bunker was made with a vertical front and a bottom that sloped from the bottom front of the bunker at an angle of approximately 45 degrees toward the back.

Instead of discharging coal from the bottom of the bunker, the spouts feeding the stoker hoppers were



CONCRETE COAL BUNKER WITH SIDE SPOUT OUTLETS

connected to the front of the bunker and were at practically the same angle as the bunker bottom. The flow of coal was controlled by a gear and rack operated gate by means of a hand chain that came within easy reach of the firemen. The illustration shows the arrangement, which appealed to me as being of very simple design. P. A. CAMERON.

Baltimore, Md.

Water-Distributing Device for Condensers

The means employed to distribute water properly over the condenser coils in a refrigerating or ice-making plant are equally as important as the proper functioning of the condensers. Condensers may be of the best design and construction, yet poor results will be obtained from them if the cooling water is not evenly distributed at all times. In either the double-pipe or surface condenser, in which the cooling water enters and leaves the condenser under pressure, no difficulty is experienced from that source. It is the atmospheric type of condenser in which the water is showered over the coils that is often found only partly covered, for the reason that the distribution of the condensing water is not uniform or constant.

Slotted water pipes or serrated gutters are commonly adopted for water distribution over condensers by the manufacturers of refrigerating machinery. In the former, water is supplied at one or two places from a cast-iron receiving box, whence it flows to either side of the box. As the ends of the slotted water pipes are closed, the water overflows through the slots in the pipe on top, after which it runs down over the condensing coils.

It is very important that the slotted water pipe be set level, since otherwise most of the water will run down from the low end.

The serrated troughs, generally V-shaped and made of galvanized steel in 10 or 20-ft. lengths, receive the water supply also at one or two places from the water-supply header, distribution being effected by overflow through the triangular or other shaped openings at the top. These troughs likewise must be placed level, as otherwise the bulk of the water will run off at the low end.

Refrigerating engineers are familiar with the fact that neither the slotted water pipe nor the overflow gutters can always be depended upon to perform their duties as might be expected, even after having been set level and the water supply properly adjusted. It is a common experience, when slotted water pipes are used, to find a surge on both sides of the supply boxes and near the ends of the pipes, the water spattering off and therefore being wasted, while the spaces between the caps and the supply boxes are found to be barely covered with water.

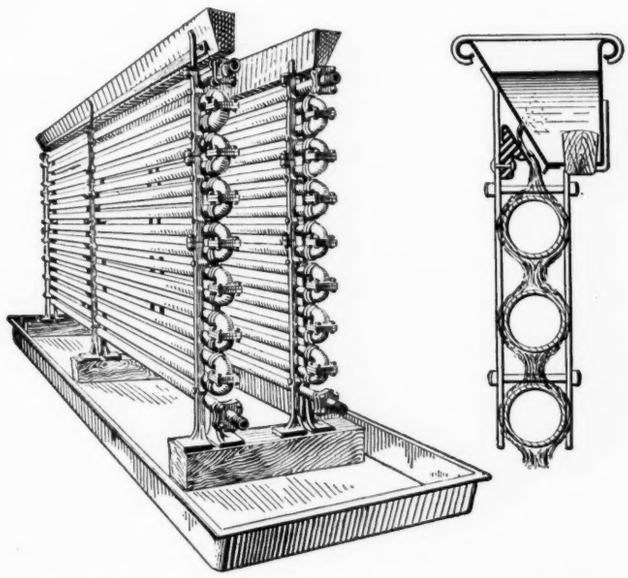
An immediate change in water distribution is brought about by increasing the quantity supplied to the water boxes. Of the two, the V-shaped condenser troughs are liable to be more seriously affected by an increased water supply; particularly is this the case when the end of the supply pipe is submerged in the trough and provided with a tee. Instead of the water following the side of the trough downward, it spurts out sideways away from the side of the trough and drops into the condenser pan without touching the pipes of the condenser.

It was with a view of correcting the shortcomings of both the slotted water pipe and the overflow gutter that a new gutter was designed and patented, which insures an even distribution of water over the condensers at all times.

As will be seen from Fig. 1, the trough has a flat bottom; one side is at an angle of about 70 deg. to the bottom, while the other side is at right angles to the bottom. Parallel to the slanting side a deflector is provided, supported by means of brackets on the clamps and made detachable so that it can be lifted out of the brackets if desired. Holes are punched in the slanting side of the trough an inch and a half from the bottom. A drip strip is provided at the bottom of the slanting side, in order to prevent water from following the bottom of the trough and spurting off to one side, in which case it would not be of any benefit to the condenser coils.

The trough is intended to be flooded with water not less than one inch above the outlet holes, so that the water always flows through the holes under a head of at least one inch. The water runs out sideways against the deflector, by which it is diverted downward vertically in a sheet of even thickness, flooding the condenser uniformly at all times.

The condenser troughs are arranged in 10-ft. lengths, using two lengths for the standard 20-ft. condenser. No great pains need be taken in leveling up these troughs, as even one inch out of level would make no noticeable difference in the water distribution, so long as the water on the high side of the trough has the outlet holes submerged at least one-half inch.



NEW DESIGN OF AMMONIA CONDENSER TROUGH

Of course no engineer would ever allow a trough to be put up in such a careless manner so as to have a 10-ft. length one inch out of line; yet if they were put up that way, the water distribution would still be found uniform provided the level mantained in the trough was above the holes at the high end.

According to the quantity of the water supplied, the water level will be high or low, but even if the trough is filled to the top the distribution remains just as perfect as before, the only difference being that the thickness of the sheet of water coming from the deflector has been increased and more water is showered over the condenser.

The bottom of the trough is provided with an opening and a wooden stopper through which any accumulation of dirt can easily be flushed out.

GEORGE M. KLENCKER,
St. Louis, Mo. Refrigerating Engineer.

Aligning Crankshaft Bearings

Our company was installing a 200-hp. three-bearing steam engine. The crankshaft was 9 in. in diameter, tapering to 7 in. for the outboard bearing. The double-spoke flywheel was 8 ft. in diameter with a 30-in. face.

The crankshaft was first swung and blocked up in the boxes on the engine frame. The flywheel was then brought forward, tipped up and slid on the shaft. Then came the undertaking of leveling the outboard bearing, since the designer of the foundation had overlooked the taper of the crankshaft and had made the entire foundation the same level. On account of the space being limited, the handling of this heavy weight and the insufficiency of the rigging, it was impossible to lower the shaft into the boxes and then bring the outboard bearing up to the proper level.

However, the outboard bearing was assembled except for its cap, on its pillar. Then, by means of a transit, the difference in elevation of the outboard bearing and the nearest bearing on the engine frame was found. This bearing was then raised to the proper level, taking into consideration the 2-in. taper. Then a mixture of cement and fine sand was poured on top of the foundation pillar to make a solid foundation. The blocking from the other two boxes was removed and the shaft lowered into the boxes. Upon testing later with a hand level on all three bearings, they were found to be in line.

Fredericksburg, Va. J. B. FICKLEN.

Discharge-Pipe Connections to Centrifugal Pump

I wish to take exceptions to Mr. Dixon's letter in the June 7 issue. It is true that substituting a long-sweep ell for the short one will decrease the friction head against which the pump mentioned works, but the work done by the pump, and therefore by the motor driving it, will be increased.

At a given speed the volume of water delivered by a centrifugal pump varies inversely with the head. The pressure produced is constant with constant speed. If one remembers that the work done by the pump depends on the quantity of water delivered and that the quantity delivered increases as the resistance decreases, one will not fall into the error of thinking that decreasing the resistance will decrease the load.

A centrifugal pump behaves like a constant potential dynamo. One would not think of lessening the load on a dynamo by short-circuiting it, which is the same thing as decreasing the resistance.

From the information given, it is evident that the motor mentioned is too small for the pump. If it is a belted outfit, reducing the speed of the pump by putting a larger pulley on it is an easy solution of the problem. The opposite of Mr. Dixon's remedy—namely, increasing the friction head by partly closing a valve—will also relieve the motor. If the full capacity of the pump at the present speed is required, then a larger motor must be used.

Last winter one of the Arizona Copper Mines closed down, but kept the power plant running to operate some pumps. The load on the power plant was so light that not nearly the capacity of the circulating pump was required. Hoping to keep the cost of producing power for the pumps below what it could be purchased for the plant engineers exerted themselves to the utmost to effect economies and studied to find a way to reduce the power consumed by the circulating pump. Finally the discharge was throttled and the wattmeter showed a 30 per cent reduction in power.

Ventilating fans behave very much like centrifugal pumps, and the same mistakes are often made in dealing with them. Decreasing the resistance to the air increases the work done by the fan because the work is measured by the volume of air delivered. With constant speed the pressure produced by the fan remains constant, therefore a decrease in resistance causes an increase of volume of air moved and, consequently, an increase of work done. G. E. MILES.

El Centro, Cal.

Motor Drives for Air Compressors

The writer was much interested in reading Gordon Fox's article in May 17 issue of *Power* under the subject of "Motor Drives for Air Compressors." There is evidently, however, a misprint in paragraph 3 below Table II, wherein he states, "Some of the larger multi-stage compressors require a power input as low as 10 to 12 hp. per 100 cu.ft. of free air for 100 lb. pressure." Inasmuch as the isothermal horsepower to compress 100 cu.ft. of free air to 100 lb. is 13.2 and since, unfortunately, it will be a long time before any compressor manufacturers can even approach the isothermal horsepower, the foregoing statement is obviously wrong. Allowing for a mechanical efficiency as high as 94 per cent, which has been obtained with careful design and workmanship, and allowing for a compression efficiency referred to isothermal of 75 per cent, we get an over-all efficiency of 70.5 per cent, which must be considered very good, resulting in the expenditure of about 18.75 hp. per 100 cu.ft. of free air. Inasmuch as the statement refers to power input, this would be further increased to over 20 horsepower input into the motor.

H. H. MILLER, Mgr., Laidlaw Sales,
Worthington Pump and Machinery Corp.

Cincinnati, Ohio.

With the Diesel Engine in India

J. J. Talaty tells, in the June 21 issue of *Power*, of some trouble he had locating a pound in his Diesel engine. I have given a great deal of thought to the case in question, and from all the evidence that he gives, I have decided that his trouble was caused by the main crankshaft being low on the right-hand end, as you look at his drawings.

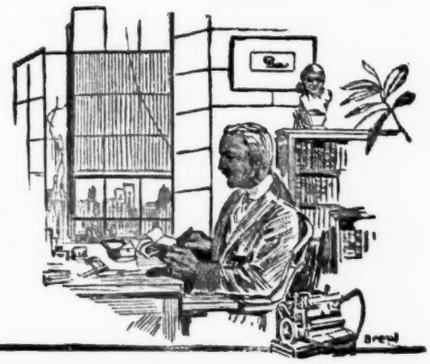
The crank bearing being worn out of true with the face indicates this, as does also the decided sidewise or shifting motion of the flywheel and crankshaft. The fact that the shim stopped the knock also proves my contention.

With one end of the crankshaft high, no matter which crankpin is passing the top dead center, one end of the pin will be a trifle higher than the other. When injection occurs, the crankpin brass will be forced to the low end of the pin, a pound will result when it strikes against the side, and the side of the brass bearing on the high end of the pin will wear the faster, there being more pressure at this point, which accounts for the brass being worn out of true.

The shaft may be level and the cylinders tipped out of the level with the shaft, which would have the same effect. EARL PAGETT.

Cherryvale, Kan.

INQUIRIES OF GENERAL INTEREST



Advantages of Outside Packed Plunger Pumps—What is the advantage of outside packed plunger pumps over piston pumps? R. E. H.

Outside packed plunger pumps are better adapted to rugged design and construction for pumping against high pressures than piston-packed pumps; it is indicated at a glance whether a plunger packing is tight and the packing is more easily renewed than piston packing. The tightness of plungers is less affected from handling gritty water than the cylinders of piston pumps, and worn plungers are easier repaired or replaced than worn water cylinders.

Chattering in Alternating-Current Magnet Switches—The no-voltage release coil on some types of starting compensators and occasionally the magnetic contactor switches on some motor controllers make a loud humming or chattering noise. What is the cause of this trouble and what can be done to correct it? J. T. H.

Humming is a defect inherent to all alternating-current magnet switches, due to the alternating flux in the iron core. It may be caused by loose laminations. However, when particularly loud, it can usually be traced to vibration of the armature, which drops slightly away from the pole-pieces at each alternation as the flux passes through zero, to be pulled back again when the flux has reversed. Most manufacturers add shading coils, or large copper rings inclosing a portion of the pole face, which produce a small field out of phase with that due to the main coil. The shading-coil field holds the armature while the main field passes through zero. If the armature is out of adjustment, however, so that it does not fit closely against the pole faces, the field produced by the shading coil becomes too weak to hold the armature, and considerable chattering may result. The only remedy is careful adjustment to give a better fit between the armature and the polepiece.

Power Required for Stream from Fire Hose—What number of actual horsepower would be required to be developed by a motor to drive a pump for throwing a stream of water from a 1⅛-in. nozzle on 100 ft. of fire hose to a height of 100 ft.? W. D.

A stream from a 1⅛-in. smooth-bore nozzle, deflected about 15 deg. from vertical, can be projected to a height of 100 ft. in a still atmosphere with a pressure of 60 lb. per sq.in. in the stream at the exit of the nozzle. The delivery will be about 288 gal. per min. with about 80 per cent of the water delivered to the full height.

The frictional resistance of best-quality rubber-lined 2½-in. fire hose, when delivering the quantity of water stated and laid without kinks or short bends, is about 15 lb. per sq.in., and the total head pressure required at the pump delivery would be about 75 lb. per sq.in. The quantity, 288 gal. per min., would require pump displacement of $288 \times 231 = 66{,}528$ cu.in., and 75 lb. head pressure would require development of $\frac{66{,}528 \times 75}{12 \times 33{,}000} = 12.6$ water horsepower.

Assuming that the efficiency of the pump that is used would be 60 per cent the net power required of the motor would be $12.6 \div 0.60 = 21$ hp. With rougher lined, kinked or a smaller size of hose the frictional resistance would be much increased and more power would be required.

Back Connection of Return-Tubular Boiler Setting—What should be the distance from the rear end of a return-tubular boiler to the back wall of the setting? C. A. S.

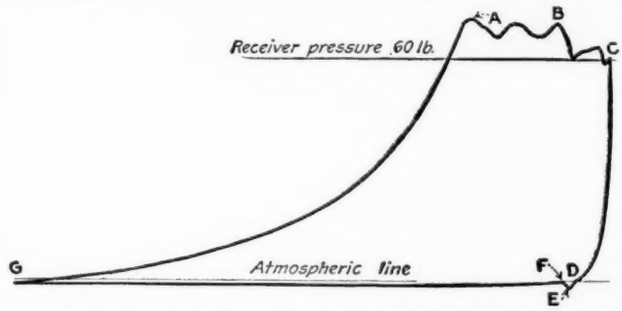
There should be a space 24 to 30 in. to give sufficient room for a man to enter the rear connection for inspection and cleaning and for expanding the tubes and renewal of fusible plugs. When sufficient space is allowed for such purposes, it will afford ample passage for conveying the furnace gases from the combustion chamber to the tubes.

Changing Speed of Shaft-Governor Engine—How is variation in speed made on an engine with a shaft governor? L. J. C.

The speed will be increased by increasing the resistance of the springs, as greater speed is then required for the centrifugal force of the weights to overcome the resistance of the springs. Conversely, the speed will be reduced by reducing the resistance of the springs. In most governors the spring resistance may be varied by changing the leverage of the springs or by varying their tension.

Indicator Diagram from Air Compressor—What causes the irregularities *ABC*, drop *E* and lowering of the air-admission line of this indicator diagram of a 10 x 12-in. single-stage air compressor, compressing to a receiver pressure of 60 lb. per sq.in.? T. A.

The diagram shows the usual performance of a single-stage compressor. The compression beginning at *G* goes



above the receiver pressure to *A*, owing to the weight of the discharge valves and the tension of the springs. From *A* to the end of the stroke the pressure drops to the receiver pressure *C*. The wavy shape of the delivery line *ABC* is due to the fluttering of the discharge valves. At the end of the forward stroke, at *C*, the piston comes to rest and the discharge valves close.

At the beginning of the return stroke compressed air that was left in the cylinder clearance space expands until the piston reaches atmospheric pressure at *D*, where the inlet valves should open, but do not open instantaneously, and expansion of the clearance air goes below the pressure of the atmosphere as shown at *E* and returns to the atmospheric line at *F* as soon as the valves open. From *F* to *G* free air is admitted, but with a drop below the atmospheric line, because the air is not admitted as fast as it should be, even continuing to the end of the stroke, although with slowing down of the piston, because the springs close the inlet valves.

Present Tendencies in Construction and Application of Economizers*

THERE is apparent at the present time a tendency to give more careful attention to the installation of economizers, especially in the larger stations, than was the case a few years ago. Two of the important factors affecting the economics of the situation are the cost of fuel and the cost of economizer equipment. While it is impossible during the existing unsettled conditions to determine with any accuracy the increase of fuel and machinery prices as compared with pre-war conditions, at the present time (May, 1921) the cost of economizers is in advance of pre-war prices by a percentage perhaps greater than obtains in the case of coal. This apparently greater increase in equipment cost would tend to diminish the incentive for using economizers. There are, however, a number of factors bearing in the other direction. Among them are the larger plants in course of installation, with resultant greater saving in dollars from a given percentage saving; the more careful engineering study being made as to the economics of power-plant construction; the higher flue-gas temperatures following from increased steam temperatures; and last but not least, the greatly improved economizer equipment that can now be purchased, as compared with a few years ago.

The use of induced-draft fans was not long ago rather exceptional, largely on account of their great size, low efficiency and troubles due to handling hot gases. The present designs of fans are, on the other hand, of relatively small dimensions and high efficiency, and some of the defects have been eliminated. In like manner the details of construction of economizers have been continually improved until now moderate pressure equipment, competently handled under usual conditions, yields fairly satisfactory service. In addition to these factors there has been during the past year great activity in new developments, following the retardation during the war. The result of all these influences is that there is a pronounced trend toward the installation of economizers, as well as of other plant equipment contributing to efficiency.

Alternative Names for Economizer

The term "economizer" fails to indicate the function of the equipment as distinguished from other pieces of apparatus contributing to fuel economy. Such names as flue feed-heater, reheater, preheater and preboiler have been suggested, and the first-named or a similar form has met with considerable approval. Flue feed-heater is a better name than economizer, and the only argument for retaining the latter is on the basis of past usage. Whatever term is employed, a distinction should be made in case the equipment becomes an integral part of the boiler, either by prefixing the adjective "integral" or appending the designation "section." One manufacturer uses the term "preheater" for this type of equipment.

New Developments in Manufacture

The manufacturers of cast-iron economizers in this country report relatively little change in general features of design, in pressure conditions for which the equipment is manufactured, or in arrangement. A considerable capacity in cast-iron economizers has, however, been installed during the last year or two. Manufacturers of steel-tube economizers, on the other hand, report many new developments, and a number of prominent American manufacturers have begun to turn out steel economizers, either in conjunction with boilers of their own manufacture or as an independent product.

The use of the integral type, or economizer section built as part of the boiler, gives a compact arrangement. In this country it is common to install integral economizer surface from 25 to 50 per cent of the boiler-heating surface, but in Europe the ratio is often much higher. A cast-iron economizer has 50 to 75 per cent of the boiler surface.

As outlined in last year's report, a combination of cast-iron and wrought-steel economizers has been used in several instances, the cast iron being for relatively low pressure and the wrought steel for high pressure. The latter takes water at a high temperature in order to eliminate corrosion. This combination necessitates a separate pumping unit, or at least a separate set of stages, between the low- and the high-pressure economizer and in general makes a rather complicated layout. Another arrangement, used by one of the largest plants in the country, is that of cast-iron economizers run at relatively low pressure, with an individual pump between each economizer and boiler. This, too, makes a rather elaborate combination, but it permits using a cast-iron economizer under low pressure. The arrangement is also favored by one of the large manufacturers.

There has recently been considerable discussion of the use of a boiler with an additional amount of heating surface as compared with the normal design of boiler with economizer. With the exception of waste-heat boilers, which are often built extra-high, there has been relatively little experience as to the heat absorption that may be expected in the last few rows of tubes. Any estimate, therefore, for the purpose of comparing these high boilers with economizer-equipped units can be considered only tentative. Comparing a 20-high boiler with a 12-high boiler used in conjunction with a 60 per cent economizer, the estimates of increased economy for the latter combination as compared with the former vary up to 5 per cent at high ratings. A recent study for a special case in the East indicated that separate economizers would pay if coal cost $8 a ton. In general it is certain that the economizer-equipped boiler will have the higher economy, as the water in the economizer is at a lower temperature than in the last row of tubes in the higher boiler, giving a greater heat differential and consequently a greater absorption.

Cast-Iron and Steel Tubes

It would be unwise to predict the result of the present activity, but for large public-utility plants there is at present considerable interest shown, both in America and Europe, in the wrought-steel type. One reason for this is, of course, the higher steam pressures coming into use, which apparently call for some material other than cast iron. The next few years will doubtless see the respective spheres of the two types fairly well outlined.

Except as regards corrosion troubles, it is apparent that the wrought-steel construction is more suitable for high pressures than the cast iron. From the point of view of corrosion, cast iron is more suitable, as less external and internal pitting are to be expected than with the wrought steel. The matter of corrosion is, of course, very important. While there has been considerable progress during the last year in the application of a number of methods of preventing corrosion, and while certain engineers feel confident of safeguarding wrought-steel tubes under reasonable conditions, other engineers are withholding judgment, and some are skeptical.

As to maximum pressures for which cast-iron economizers should be designed, engineering opinion varies from 150 to 350 lb.; a common opinion sets the limit at about 250 lb. per sq.in. There are a few instances of cast-iron economizers failing under high-pressure tests, and it is now recommended by manufacturers that preliminary tests be kept well within the elastic limit of the economizer material. It has been found in one instance that headers have split due to the occurrence of one or more tubes a little larger in diameter than the remainder, and the recommendation has been made that all tubes be carefully gaged before the row is assembled in the header.

Wrought-steel economizers are in general less bulky and,

*Abstract from 1921 Report of Prime Movers Committee as presented at the forty-fourth convention of the National Electric Light Association, Chicago, Ill.

especially for the higher pressures, less expensive than cast iron. On account of their smaller size it is somewhat easier to work the steel-tube economizers into the design of a plant, and especially to provide a compact boiler-economizer unit. It is frequently possible to house the boiler and economizer in what is substantially a single setting, which tends to eliminate leakage and radiation losses. Against any advantages of steel economizers, however, should be offset the space, cost and complications entailed by the safeguards against corrosion. It is believed, given the usual respective conditions of installation for the two types, that wrought-steel economizers show a better heat transfer than the cast iron. An important feature in this is the size of the tubes, which in the case of cast iron are commonly 4 to 5 in., and in the wrought steel are now frequently 2 in. in diameter.

Corrosion and Its Remedies

The following is a summary of the experience of three American steam plants with steel-tube economizers or economizer sections:

A. This station has been in operation several years. The tubes of the economizers were galvanized inside and out, and no external corrosion has been observed, but there has been considerable internal pitting, with feed water from 130 to 150 deg. F. On the inside of the tubes small particles of iron oxides collected, which upon removal left pits, sometimes $\frac{1}{8}$ in. deep. The curative measures employed have been a thorough painting of the interior surfaces with high-grade carbon paint, the closing of the vents on the feed-water heater to prevent circulation of atmospheric air in the heater and the use of steel turnings placed in the bottom of the heater. The rapidity of the pitting action has been greatly reduced, and it is felt that such corrosion as is now going on is not serious.

B. This plant has had steel-tube economizer surface in operation for a considerable period. In the beginning serious corrosion was experienced, which was traced to free oxygen in the feed water. The feed temperature was 160 deg. F., this water containing about 3.5 cubic centimeters of oxygen per liter at the inlet, and only 0.25 to 0.5 at the outlet. Upon increasing the temperature of the incoming water to 212 deg. F., practically all the oxygen was removed and the corrosion has apparently stopped.

C. This plant has not been in operation so long as the others. In the beginning considerable internal corrosion in the tubes was experienced, but a painting of the inside of the tubes with carbon paint—which they recommend be done when an economizer is new and repeated periodically—has decreased the rapidity of the pitting. A trial of steel shavings to remove the oxygen from the water was unsuccessful, as these shavings became covered with mud and were not oxidized. It is the opinion of the engineers that if the temperature of the water is between 190 and 200 deg. F. the corrosion will practically stop.

Example of Maintenance Cost

A large operating company kept records through 1920 as to the cost of maintenance for eight 8,256-sq.ft. cast-iron economizers. The cost for eight economizers was about $3,500 in labor and $1,500 in material, a total of $5,000. During the year there were 20 tubes (about 0.5 per cent) replaced in the eight equipments, at a cost of a little over $20 a tube. All economizer tubes were bored once during the year, at an average cost of 25 cents a tube, or about $1,100 for all.

Methods Employed in Cleaning

Manufacturers of cast-iron economizers are inclined either to favor soot scrapers or to put them on a par with steam soot blowers. Operators are divided in opinion, but probably more than half the new installations are equipped with blowers. The engineer of one important station has found that scrapers tend to compact the soot on the tubes and therefore he uses soot blowers, together with occasional scraping by hand. It is usually recommended that a steel-tube economizer be cleaned by means of a soot blower, sometimes in conjunction with a hand lance. The Foster economizer, using cast-iron rings covering the tubes, is supposed to use either a soot blower or a water-flooding process for cleaning.

As to troubles arising from sludging or scaling in economizer tubes, certain waters will, of course, throw down solids at a temperature just above that of exit from the feed heater, so that each set of conditions must be treated by itself. In case of deposits of foreign matter, blowing down must be resorted to, and when scaling occurs a turbine cleaner should be used as often as necessary to preserve good heat transfer. Several important plants make a practice of blowing down economizers once or twice each week to remove loose scale and sluge; also of boring out the tubes once a year or oftener. Another blows down the economizer occasionally, but has not "turbined" the tubes during two years of service.

Induced-Draft Fans and Air Infiltration

In general it is necessary to provide induced-draft fans for economizer installations. One boiler manufacturer, turning out a one-pass boiler and providing therewith a relatively small economizer, states that the combined draft resistance is low enough to be supplied, even up to 200 per cent rating or over, by a reasonably high stack. Such an arrangement should, of course, be used with caution, for it is not infrequently the case that the use of high-refuse coals tends to build up a deposit between the first rows of boiler tubes, much increasing draft resistance and forcing an early shutdown if ample excess draft is not provided. In using a natural draft also, it is important that air infiltration be kept as low as possible, not only in the boiler and economizer settings and casings, but also in smoke flues leading to the stack.

In a number of cases of economizer installations made during the last few years it has been found that the fans were of too small capacity to handle the desired overloads. This has apparently been due in large measure to amounts of excess air much beyond what was expected. Some engineers figure 10 to 20 per cent air infiltration in an economizer setting alone, and there is often a large amount passing into the boiler setting, especially in a multiple header boiler. It is also frequently the case that smoke flues are far from tight, especially at riveted and expansion joints. One plant reports the infiltration between a large boiler and cast-iron economizer to be relatively small (about 500 to 2,000 cu.ft. of air per minute), but the infiltration through the economizer casing and stack uptake to be greater, ranging from 4,000 cu.ft. with air leaks cemented up to 20,000 cu.ft. in an extreme case. Another station, with steel-cased economizers, reports negligible infiltration. In general, great care in design, construction and operation must be exercised, or the induced-draft fan must be made larger than ordinary theoretical allowances would indicate. The result of high excess air is, of course, to increase the volume of the flue gases and also the draft required. As modern fans have definite draft-volume-speed characteristics, the results are often to throw the fan performance beyond proper limits.

Fuel Cost to Justify Economizers

Since the fuel saving should justify the increased charge resulting from the economizer installation, one of the principal factors in determining the advisability of installing economizers is the cost of fuel delivered into bunkers at the plant. In order to illustrate the method of determining the approximate price of fuel that will justify an economizer installation, the following case has been assumed and savings worked out:

1. Station of three 10,000-kw. machines, two in operation on higher loads.
2. Maximum hour generation 18,000 kw.-hr., minimum 4,500 kw.-hr.
3. Day-load factor 50 per cent, based on maximum hour generation.
4. Four boilers, each 12,000 sq.ft. B. & W. cross-drum type, 14 tubes high, 48 tubes wide.
5. Cast-iron economizers, each 7,200 sq.ft.
6. Stokers, inclined underfeed, extra long, each 16 retorts.
7. Steam conditions (average) at boilers, 250 lb. gage, 200 deg. F. superheat.

8. Steam conditions (average) at turbines, 235 lb. gage, 175 deg. F. superheat.

9. Station water rate 15.2 lb. per kw.-hr. generated.

10. Fuel, Eastern bituminous coal, 13,500 B.t.u. per lb.

It is also assumed that the station is so designed that there is sufficient exhaust steam to heat the feed water to an average temperature of 200 deg. F., and that of the four boilers, all are in operation during the heavy day load, except at such times as one is necessarily out of service for repair. The size and number of boilers assumed gives an average boiler rating, during the hours of maximum generation, of approximately 200 per cent of normal for four boilers, or 270 per cent when only three are available.

The operating schedule under the assumed conditions shows an average boiler rating of 140 per cent, at which rating the temperature of the escaping gases will be approximately 520 deg. F. Within the actual range of boiler operation encountered under this operating schedule, the rise in temperature of the feed water will not vary more than a few degrees, and it is estimated that the average rise will be 85 deg. F. Based on this assumption and on 1,130 B.t.u. being imparted to each pound of water evaporated, the fuel saving by the use of economizers will be 7.5 per cent.

Assuming the investment for economizer surface to be $5 per square foot installed, including fans and connections (but without allowance for additional cost of building to house economizers), the total cost for 60 per cent economizer surface will be $144,000. If annual fixed and operating charges on this investment are taken at 20 per cent, they will be $28,800.

Based on the 50 per cent day-load factor, the total energy generated daily is 216,000 kw.-hr., and if this applies for 300 days per year the annual generation is 64,800,000 kw.-hr. Assuming an average stoker and boiler efficiency of 67.5 per cent, the annual fuel consumption per year without economizers will be about 61,000 net tons. A 7.5 per cent saving on this tonnage would be 4,600 tons. For the fuel saving to balance the annual increase in charges due to economizers, the cost of fuel delivered to bunkers must be $28,800 ÷ 4,600 = $6.25.

If it be assumed that a fifth (spare) boiler is to be provided, the economizer investment would be increased to $180,000, and the fixed and operating charges to $36,000 per year. Under these conditions the price of fuel at which the fuel saving would just offset the increase in fixed charges would be about $7.80 per net ton.

It should be kept clearly in mind that the foregoing is merely a rough analysis, and that the only thoroughgoing method is to design a complete plant without economizers and then with, and estimate the total cost of energy from each.

Limitations of Mechanical Stokers Utilizing Mid-West Coals*

By Edward H. Tenney

Mid-West coals are classed as bituminous or sub-bituminous, and are characterized by the higher percentages of moisture, volatile and ash which they contain as compared with Eastern coals:

TABLE I. COMPARISON OF TYPICAL MID-WEST AND EASTERN COALS

Constituents of Coal	Pocahontas	Southern Illinois
Moisture, per cent	2.21	11.90
Volatile, per cent	15.78	31.06
Fixed carbon, per cent	71.65	41.62
Ash, per cent	10.36	15.42
	100.00	100.00

On account of these characteristics they are inherently difficult of satisfactory handling on a stoker, but they present possibilities for even greater operating economies than in the case of Eastern coals because of the opportunities provided for even firing, close regulation of air supply, high temperatures, and a continuous and regular elimination of ash.

The moisture content in Mid-West coals ranges from 6 per cent to 16 per cent, depending largely upon the amount of surface moisture which may be present.

High volatile content is the one redeeming feature of the Mid-West coals, inasmuch as this quality tends to facilitate ignition.

The ash content of these coals varies from 10 per cent to 16 per cent, depending on the method of mining and storing, and presents one of the most difficult limitations to their use on mechanical stokers. Large quantities of incombustible matter interfere with combustion if allowed to remain in the active fuel bed. This is increasingly true at high ratings, especially so on account of the low fusing temperature of the ash, which results in the formation of clinker and prevents proper air supply. Table II, prepared by Edwin Lundgren,[1] shows the increase toward fusibility as percentages of certain constituents change, more particularly the ferric oxide. Ash from Mid-West coals comes between "clinkering" and "bad" in the table.

TABLE II. TYPICAL PERCENTAGE ASH ANALYSES

Composition	Non-Clinkering	Fair	Clinkering	Bad
Silica (S_2O_i)	54.67	46.23	46.40	43.50
Aluminum (Al_2O_3)	41.95	31.93	16.45	17.10
Ferric oxide (Fe_2O_3)	Trace	14.54	18.15	28.10
Calcium oxide (CaO)	1.82	5.04	11.80	5.30
Magnesia (MgO)	1.42	2.26	4.63	0.75
Sulphur	0.55	1.50	3.00	2.70

The subject of air supply to stokers utilizing Mid-West coals is of equal fundamental importance to that of the fuel itself. In the burning of low-grade coals the distribution of air through a fuel bed heavy with ash and clinker is not conducive to its proper mixture with the combustible gases, with the result that combustion is incomplete when the gases have passed from the furnace. Such coals require large quantities of excess air, which, on account of the interference set up by the fuel bed, tend to travel in stratified streams. The mixing, therefore, is incomplete and the combustion slow.

The furnace itself presents another important limiting factor in the utilization of low-grade fuels. With 50 per cent excess air and burning at the rate of 50 lb. per sq.ft. of grate area per hour, developing to within one-half of one per cent complete combustion of the flue gases Mid-West coals require about 2½ times as much furnace volume as the Eastern.

Stoker limitations may also be imposed by the arrangement of boiler baffling. For high overratings with Mid-West coals very large volumes of flue gas must be handled. Resistance to the passage of these gases through the setting increases as the square of their velocity. Draft pressures must therefore be adequate to overcome these high frictional losses or capacity will be limited. Location of baffles to give uniform velocities throughout the path of gas travel, is also an extremely important phase of boiler and furnace design.

The problem of ignition offers another limiting factor in the operation of stokers using Mid-West coals, especially at high overratings. Furnace design must permit of the concentration of sufficient heat at the point of entrance of the fuel to accomplish a rapid distillation and strong ignition of the hydrocarbons. The necessity for, and the practice of, installing a properly designed reflecting arch to accomplish this is well known. The high volatile percentage of our Mid-West coals tends to facilitate ignition and is especially favorable when the volatilization may be accomplished rapidly and at comparatively low temperatures.

Effect of Limitations on Operation

With chain-grate stokers and natural draft maximum capacity is limited to the burning of from 40 to 45 lb. of coal per square foot per hour, except at a large sacrifice in efficiency. Above this ashpit loss increases excessively, and it is almost impossible to maintain ignition. In the case of forced-draft chain grates the limits as to rates of combustion are considerably higher, and greater flexibility of operation is also obtained through a more definite control of air supply.

With the overfeed type of stoker, under natural draft, a

*Abstract of paper presented before The American Society of Mechanical Engineers at the Spring Meeting, Chicago, May, 1921.

[1]Vice-president and chief engineer, Frederick Engineering Co., Frederick, Md.

coal consumption somewhat less than that obtainable on the chain grate is generally recognized, say, 30 lb. per sq.ft. per hour. Trouble from the avalanching of the fuel bed is reported beyond this rating resulting in breaks and bare spots within the fuel bed and temporarily limiting both efficiency and capacity. With forced draft over-ratings may be extended up to 60 lb. per sq.ft. per hour.

In the case of the underfeed stoker and forced draft a quick response may be had to all changes in load, resulting in an exceedingly flexible control. For continuous operation the maximum amount of coal that can be burned successfully seems to be from 900 to 1,000 lb. per retort per hour. For high overratings over short periods a combustion rate of 1,400 lb. per retort per hour may be established. The limiting features as to capacity and efficiency in the underfeed stoker utilizing Mid-West coals lie mainly in the high ash content of the fuel and its low fusibility, which at high overratings result in clinker formation and sometimes in the fusing over of the entire surface of the fuel bed adjacent to the dump plates.

In conclusion, it may be generally stated that the application of mechanical-stoking equipment to the use of Mid-West coals has proved to be eminently successful. The peculiar characteristics of the fuel have called for especially designed arrangements for air supply and for ignition. Furnace volumes and gas passes have also had scientific attention, with the result that the most difficult problems, namely, those incident to operation at high rates of combustion, have been satisfactorily solved. The particular type of stoking equipment best adapted to these coals may be specified as that one which most fully overcomes the many limitations to capacity and efficiency which have been found to exist.

New England N. A. S. E. Meets

The Annual Convention and Mechanical Exhibit of the New England States Association of the National Association of Stationary Engineers was held in Infantry Hall, Providence, R. I., July 13 to 15. Sixty-two official delegates were present, together with a large number of guests and exhibitors. Over eighty manufacturers of mechanical appliances had their products on exhibit.

The mechanical exhibit opened on Wednesday evening with President Harry H. Atkinson in the chair. Hon. H. J. Gross, Lieutenant Governor of Rhode Island, welcomed the delegates in the name of the state, and response was made by Major James W. H. Myrick, treasurer of the New England Association of Commercial Engineers, who spoke of the ideals of the N. A. S. E. and how the association had lived up to them as set forth in its preamble. Other addresses were by E. E. Salisbury, president of the Providence Chamber of Commerce, who referred to the important roll that Providence had played in the early days of the steam engine; H. Nelson Street, also of the Providence Chamber of Commerce; and F. S. Eggleston, Jr., chairman of the Exhibition Committee.

The opening exercises of the association occurred Thursday evening. Chairman Albert H. Keene introduced Mayor Gainer of Providence, who welcomed the delegates in the name of the city and referred pleasantly to a previous visit of the association seven years ago, also to the fact that the N. A. S. E. had had its inception there. Dudley G. Kimball, president of the New England States Association, N. A. S. E., responded to the Mayor's address and referred at some length to the work of Corliss and Horace Mann, the latter as a pioneer in educational work along mechanical lines. Other addresses were by Edward H. Kearney, Past National President, N. A. S. E.; M. H. Bronsdon, of Providence; and Past National President Theodore N. Kelsey, who referred to the abnormal conditions of the last few years which rendered the work and remuneration of the operating engineer less attractive than many other mechanical lines. However, present conditions are tending to restore the prestige of the operating engineer. The following convention committees were appointed: Credentials—Llewellyn M. Reed, of Boston; Argyle T. Johnson, of Manchester, N. H.; I. F. Moulton, of Lowell, Mass.; auditing—H. M. Milway, of Boston; Philip Hanson, of Hartford; Charles A. Stocks, of Attleboro; ways and means—Edward J. Grace, of Bridgeport; George H. Shaw, of Pawtucket; Robert Johnson, of Westboro, Mass.; constitution—Theodore N. Kelsey, of Lowell; Charles E. Hixon, of Attleboro; Samuel C. Kinterbottom, of Pawtucket.

At the closing session of the delegates the following officers were elected and installed: Dudley G. Kimball, president, Boston, Mass.; James H. Henderson, vice president, Hyde Park, Mass.; Warren H. Goodrich, past president, Syracuse, N. Y.; Freeman L. Tyler, secretary, Taunton, Mass.; Walter H. Damon, treasurer, Springfield, Mass.; John R. Graham, conductor, Fall River, Mass.; Thomas Livingston, doorkeeper, Meriden, Conn.

The New England Association of Commercial Engineers elected its officers on Friday morning as follows: Sanford C. Smith, president, McClave-Brooks Co.; Henry H. Lynch, vice president, Hodge Boiler Works; James H. Morgan, secretary, Boston; James W. H. Myrick, treasurer, Autoforce Ventilating System. The directors included Harry H. Atkinson, Economy Lubricating Co.; Claude D. Allen, Garlock Packing Co.; John A. Morehouse, Eagle Oil & Supply Co.

The executive committee of the Power Show, connected with the International Textile Exposition which will be held in the Mechanics Building, Boston, Mass., Oct. 31 to Nov. 5, 1921, includes F. S. Eggleston, chairman; James W. H. Myrick and Charles F. Ceilley. During the last fiscal year thirty firms have been added to the membership.

On Friday evening at 9:30 the Exhibit Hall was closed and the delegates, supplymen and guests retired to the main hall on the upper floor, where a smoker was held. An inviting buffet lunch was served, followed by an enjoyable vaudeville performance. It was decided to hold the next convention at Springfield, Mass., in July, 1922.

Henry Ford Offers To Take Over Muscle Shoals Plant

Henry Ford's habit of doing big things in a big way has once again asserted itself; he has now offered to take over the Wilson dam and Nitrate Plant No. 2.

Mr. Ford's proposition, and this has been confirmed at the Department of Commerce, is as follows: He offers to lease for 100 years the Wilson dam and the near-by No. 3 dam, along with the electrical installation, when the project is completed. It is estimated that an additional $28,000,000 must be expended for the completion of the dam. On that sum Mr. Ford proposes to pay interest at the rate of 6 per cent, and to amortize not only this sum, but the entire cost of both dams over a period of 100 years. In addition he offers $5,000 000 for the outright purchase of nitrate plant No. 2, its auxiliary steam plant, the land necessary to the operation, and other appurtenances. He agrees to operate the nitrate plant for the production of fertilizers and to make the necessary conversion to the new use. He agrees also to maintain the plant so that it may be converted promptly for the manufacture of explosives in case of war. The apparatus is to be kept up to date in both arts. He agrees also to limit the fertilizer plant profits to 8 per cent.

Mr. Ford expects to use a part of the power not needed for the nitrate plant for some of his own manufacturing enterprises, and in addition it is assumed that he will undertake to find buyers for the surplus power. The Secretary of Commerce authorized the following statement in regard to Mr. Ford's proposal:

The acceptance of the offer is matter for decision by Congress, and that body will no doubt be greatly guided by Secretary Weeks' views in the matter. Mr. Ford has made a genuine proposal. It shows courage to agree to pay out $5,000,000, to spend further sums upon large works and besides to take an annual obligation for about $1,500,000 for 100 years and to agree to maintain a nitrate plant in reserve for the government for that period. Whatever may be the result, Mr. Ford's offer does prove what the public associations have contended—that the completion of this project has a commercial value.

The Secretary of Commerce revealed on July 18 that Henry Ford is not the only private interest considering the Muscle Shoals power proposition. Secretary Hoover stated that various chemical and power companies were considering the matter and indicating an active interest in it.

Report Made on St. Lawrence Waterways Project

A report on the proposed Great Lakes-St. Lawrence waterways project has recently been completed by Col. W. P. Wooten, for the United States, and W. A. Bowden for Canada. The report has been submitted to the International Joint Commission at Washington, which is in charge of the project.

The plan is primarily intended to provide a navigable waterway from Lake Ontario to Montreal, in which distance there is a drop of 220 ft. The possibility of combining a power development with the waterway has not been lost sight of, however, and it is recommended in the report that a power plant be built at Long Sault Rapids near Ogdensburg, N. Y., with a total capacity of 1,464,000 hp. The total horsepower that could be developed from the St. Lawrence River is estimated to be over 4,000,000, but it is not considered that a market for that amount of power exists in that district at the present time.

The cost of making the route navigable to deep-sea vessels is put at $252,723,200, which is based on a channel depth of 25 ft. Provision is made for increasing the depth to 30 ft. if desirable, at a further cost of $17,986,180. The yearly maintenance cost is put at $2,562,000.

Carbonization Committee Planning Annual Report

The Carbonization Committee of the American Gas Association met recently to make final plans for the annual report in the fall. It is planned that the manufacturers' group on this committee will summarize all new methods of carbonization of interest to the gas industry by brief descriptions of the plant and processes. The operating subcommittee will report upon as many plants as can be investigated carefully, showing typical operating results for new plant developments. The low-temperature carbonization subcommittee will give similar attention to methods, results and general prospects for low-temperature carbonization of coal. Particularly it is hoped to have consideration given to the economic possibilities of such systems and a discussion of the place that they will fill in the general fuels work of the country.

J. H. Taussig, of the United Gas Improvement Co., Philadelphia, is general chairman. The subcommittee chairmen are: Manufacturers' subcommittee, F. G. Curfman, Improved Equipment Co., New York City; operating subcommittee, W. H. Earle, Rochester Gas and Electric Corporation, Rochester, N. Y.; low-temperature carbonization subcommittee, J. D. Davis, Bureau of Mines, Pittsburgh.

Oil To Be Tax Free

By a vote of 196 to 86 the House of Representatives on July 18, sitting as a committee of the whole, voted to amend the Fordney tariff bill by removing crude petroleum and fuel oil from the dutiable list and placing them on the free list. A record vote will be taken on the question in the House proper, but it is practically certain that the vote in the committee of the whole will be sustained.

An unusual situation was presented in that the return of petroleum to the free list was urged by the governor of Massachusetts, while the governor of Louisiana used his influence in an effort to retain it on the dutiable list. This is typical of the departure from party alignments. Representative Treadway, of Massachusetts, in his speech advocating free petroleum, said in part:

For some time, particularly in the New England section, there has been a great difficulty in procuring coal. Transportation problems have faced us and we have not been able to reach the supplies of the mines and deliver the coal to the industries wanting it. As a result throughout New England many industries have turned from coal to oil as a fuel for power. It has been shown that by placing a duty on oil equivalent to 1 cent per gallon you will add to the expense of manufacturing in Massachusetts alone the enormous sum of $5,000,000. Either we must add this amount to the cost of production or return to coal, consuming 2,750,000 tons. This is a matter purely of conservation of our natural resources added to the cost of production. There can be no better argument it seems to me for the return of this great product to the free list than these figures, which illustrate solely the situation in the manufacturing industries of one state alone. When you add to that the enormous quantity of oil consumed in such great centers as New York and Philadelphia and our other large cities, as well for heat and light as for power, the amount ultimately charged to the consuming public for this one item of putting a raw product onto the protective list runs into untold millions of dollars.

The reply to the foregoing argument was made by Representative Blanton, from Democratic Texas, who pleaded for the full amount of duty recommended by the committee for petroleum and fuel oil. A portion of his argument was as follows:

There are at this time a number of little independent oil companies which, at great expense, have been developing oil in Texas and Oklahoma. In Mexico, just across the Rio Grande, there are a number of valuable oil fields owned by the Standard Oil Co. and its subsidiary corporations. Practically all of the oil properties in Mexico are held by such interests of the Standard Oil Co. The oil down there in Mexico is largely developed by using cheap Mexican peon labor for about one-fifth of what it costs to develop oil in Texas. With no duty on this cheap Mexican oil, the Standard Oil Co. has cut the price of crude petroleum down so low that it has practically ruined the small independent oil companies, though it has still held up its price on gasoline. If it can continue to bring cheap Mexican oil across the Rio Grande free of duty it will accomplish its purpose of running out of business all competition, and then New England, and everybody else, had better watch out.

New York State Boiler-Inspection Service Reorganized

The New York State Bureau of Boilers and Explosives, which had charge of all boiler-inspection work in the state, has been abolished, and the Bureau of Inspection has been organized to take over its work as far as boilers are concerned. One of the divisions of the Bureau of Inspection will be the Division of Boiler Inspection, which will be in charge of a chief boiler inspector. The first appointee to this position is William H. Furman, who has been serving as acting chief of the old Bureau of Boilers and Explosives since the death of George A. O'Rourke.

The division's boiler inspectors are to inspect all boilers carrying a pressure of more than 15 lb. per sq.in. The division will also have charge of the records of boilers inspected by duly authorized insurance-company inspectors and is to have supervision over the issuing of certificates of competency to the insurance companies' men. Mail should be addressed to the Division of Boiler Inspection, Department of Labor, Capitol, Albany, N. Y.

A safety valve should be of ample size and kept in working order. It should be tried daily by allowing the pressure to rise gradually until the valves just "simmer," noting the pressure by the steam gage at the moment. Freedom of action may, of course, be ascertained by hand, but it cannot be known by this means that the valve will blow off when the proper pressure is attained. Neglect and overloading of this most important adjunct are prolific causes of boiler explosions. Each boiler should have its own safety valve and no stop valve should be permitted between it and the boiler.

An important market for hydraulic-power equipment exists in Switzerland, according to the United States Bureau of Foreign and Domestic Commerce. Close to 90 per cent of the country's fuel is imported, so that hydro-electric development is recognized as especially desirable and is being pushed actively. The total water power available is put at 2,173,238 hp., of which 526,098 hp., or about 25 per cent, is being utilized. The number of plants is 6,860.

Ireland's potential water-power resources amount to half a million horsepower that could be made continuously available, according to Consul William P. Kent, of Belfast. This estimate was made by a committee that has recently been making a survey of Ireland's water resources.

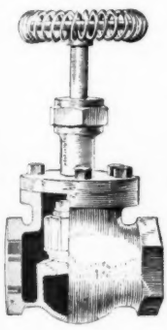
Condensed-Clipping Index of Equipment

Patented Aug. 20, 1918

Valve, Fisher Compound-Seated

Fisher Compounded-Seated Valve Co., Providence, R. I.

"Power," 1921



A compound seated valve having four seats and four discs, in which the smallest disc seats on the smallest seat, while the next largest disc is $\frac{1}{32}$ in. from its seat, the next is $\frac{1}{16}$ in. and the fourth is $\frac{3}{32}$ in. from its seat. The seats are flat and the walls have a slight bevel to allow for the expansion of steam when the valve is cracked and this prevents cutting of the other seats. The disc does not turn when the valve is operated. When the smallest seat begins to leak it is removed from the valve and filed off $\frac{1}{32}$ in., which allows the second disc to come in contact with the second seat. This is repeated until the last disc is reached.

Indicator, Crankshaft Alignment

Ruscon & Hornsby Co., Ltd., Lincoln, Stockport, England (*The Engineer*, London).

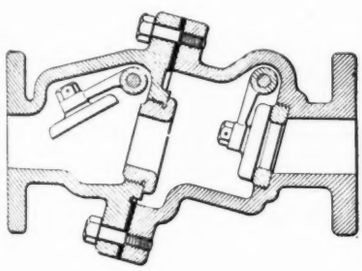
"Power," June 14, 1921

An alignment indicator used in the alignment of crankshafts of new engines and for checking the alignment of crankshafts of engines in service. It consists of a dial provided with a scale graduated in thousandths of an inch and a pointer that is actuated by a spring plunger. Two additional spring plungers are arranged on either side of the central plunger. The apparatus is employed to measure the distance between the inner spaces of the crank balance plate or of the outer end of the crank webs, first when the crank is in one position and then when it has been moved one-half revolution. The difference in the reading of the pointers indicates how much the alignment is out of true. The instrument is adjustable for use in any size of crankshaft in which the distance between the web is not less than $4\frac{1}{2}$ in., nor greater than $9\frac{1}{2}$ in.

Valve, Farnsworth Double-Swing Check

Farnsworth Co., Conshohocken, Penn.

"Power," 1921



Tightness is insured by the design of this valve, inasmuch as there can be no wiredrawing or cutting of seats, because dirt would hardly lodge under both discs at the same time. If there is any dirt or sediment under one disc, it will not be under the other, hence one disc will be tight even though the other is obstructed from closing. The seat and disc are removable and the check valve is furnished with screwed or flanged ends. It is adapted to boiler-feed lines.

Pump, Exeter Rotary

Exeter Machine Works, Inc., 30 Church St., New York City.

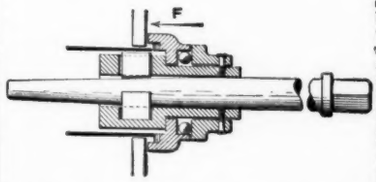
"Power," 1921

The pump consists of an outer casing of cylindrical form having a pair of rotors meshing, the inner rotor being keyed to the driving shaft. These two rotors are set eccentric one to the other. The outer rotor has four ports, which are open to the chamber of both the suction and the discharge side of the pump during rotation. These ports are closed momentarily by a lip at both the top and the bottom of the pump body to effect the cutoff between the suction and the discharge of the pump.

Expander, American Tube Projecting

Reinhold Betterman, Johnstown, Pa.

"Power," 1921

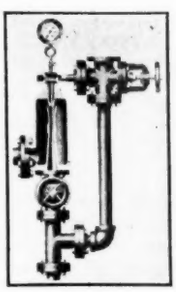


This tool consists of two expander rolls, expander body, a guard and gage, a thrust collar bearing against anti-friction rollers, and a mandrel. When using this expander, the tool is inserted into the tube and presses against it until the guard comes in contact with the tube; at the same time the guard forces the tube through the hole until the right projection is automatically obtained. When power is applied to the expander pins, revolving the expander body and forcing the roller to travel around the interior of the tube with the collar following the same motion, this acts as a press against the roller bearing and permits the guard to remain stationary through the process of expanding the tube. The two forces created as a result of the self-feed action causes them to balance each other with the result of gaining uniform tube projections to the amount of stock necessary for beading purposes.

Compressor, G-R. Regenerative

Griscom-Russell Co., 90 West St., New York City.

"Power," May 17, 1921

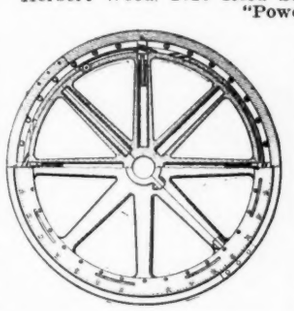


This regenerative compressor is designed for installation on Reilly evaporators, and its use during periods of reduced evaporator capacity permits the evaporator to operate at an efficiency much greater than can be secured when the evaporator is operating alone, single effect. This is accomplished by compressing and delivering to the evaporator coils a portion of the vapor taken from the evaporator which, together with a certain amount of boiler steam, makes up the total steam required for evaporator operation. Without the use of the regenerative compressor all the steam would have to be supplied by the boiler.

Wheel, Wood's Disconnecting Belt

Herbert Wood, 2020 Reed St., Philadelphia, Pa.

"Power," 1920

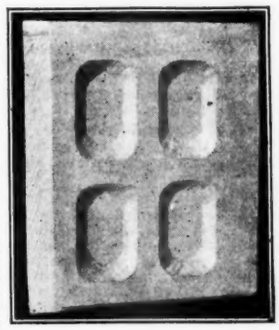


This wheel is designed to provide a combination with a pulley having a normally loose belt-carrying rim that may be locked to a fixed rim of the wheel and released from it so that the body of the wheel may be revolved independently of the rim. The loose and fixed rims are locked by rim-locking plungers, carried in the bore of certain spokes, also springs that draw the locking plungers out of engagement with the plunger sockets in the wheel rim. The locking plungers are forced outwardly by means of a pinion and rack, the latter being on a locking ring, which forces inclined operating tongues into suitable inclined grooves in the locking sockets, thus causing the rim to rotate with the rest of the pulley. A projection on the locked rim is arranged to strike against a movable projection to unlock the rim.

Baffle Interlocking Sectional Tile Stirling Boiler

S. F. Brooks, C. C. C. St. L. Ry. Co., Indianapolis, Ind.

"Power," 1921



A new design of an interlocking and overlapping sectional tile baffle for Stirling boilers. This baffle lies flat on the tubes and remains leakproof under all heat conditions of the boiler. Also the faces of the baffle sections are recessed to prevent a too rapid movement of the gases, so as to more effectively use them and cause a more effective intermixing of the gases, resulting in more complete combustion.

Clip, paste on 3 x 5-in. cards and file as desired

Washington News

"Buy Coal Now" Advises Secretary of Commerce—Methods of Gathering Coal Data Discussed—Water-Power Applications Allowed

By Paul Wooton
Washington Correspondent

The Secretary of Commerce made public on July 18 the text of a letter that he has addressed to all the public-utility associations. The letter reads:

I would like to call the attention of your association to the bituminous-coal outlook. There is every indication that there has been an undue slackness in the purchase of coal, which may accumulate to large demands in the autumn. I am convinced that, due to the general depression, the prices of bituminous coal at the mines are not too high at the present time. This, I think, is proved by the fact that numbers of operating coal companies are making no profit whatever. If there should be a recovery of business activities in the autumn, taken in conjunction with the large increase in percentage of disabled cars (from 5 per cent to 16 per cent during the past six months) and the inability of the railways to finance their maintenance, there are possibilities of development of a most serious situation as regards coal movement.

I cannot but feel that the Interstate Commerce Commission, in the face of warnings they have sent out in this connection, would not be disposed to give any priority in such an event. It seems to me, therefore, to be obvious that the public-utility companies, both in their own interests and the protection of the public, should make early provision for stocks of coal sufficient to carry them over a critical period.

Coal Reports Discussed

The National Coal Association has given its president, J. G. Bradley, full authority to use his own judgment in negotiating with the Secretary of Commerce as to what statistics the association will furnish voluntarily in the matter of production, distribution and average sales realizations. The only limitation placed on Mr. Bradley by the Board of Directors was that he receive assurance from the Government that these voluntary reports will not be considered as violating the Sherman law. Acting under the authority given him, Mr. Bradley and J. D. A. Morrow, the vice president of the association, plan to discuss the matter with Secretary Hoover in the near future.

Secretary Hoover stated on July 18 that he contemplates making no request of the operators to furnish voluntary statistics. He said that the new coal commodity division would get its figures as to production from the United States Geological Survey. As to price information, he stated that he preferred securing it from sources other than the operators, since it would be regarded by the public as being more authentic when obtained from sources other than those who produce coal. Mr. Hoover made it clear that this was no reflection on the operators, as it is natural that prices emanating from them would not be given the same weight as would those that could be collected otherwise. In addition, Secretary Hoover expects to collect data as to stocks, in which the operators could not be of assistance.

Power Commission Busy

After having heard from the Chief of Engineers in person as to the application of the Arkansas Hydro-Electric Development Co., the Federal Power Commission, at its meeting July 11, withdrew its objection and voted that the project will not affect the interests of interstate commerce. The project is on the Little Red River in White and Cleburne Counties, Arkansas. The company proposes to build a dam near Judsonia to raise the water to a sixty-foot level and to build a second dam near Higden to raise the water level seventy feet, thereby storing some nine billion cubic feet of water. The Chief of Engineers held that the Little Red River above Bee Rock, six miles below the proposed power development, is not navigable. Even below that point it is navigable only by back water from the White River.

The commission approved applications in several cases, among which were the following: A preliminary permit for project No. 17 in favor of the Western Tie and Timber Co., for a power development near Eminence, Shannon County, Mo., in the Current River, a project that is rated as being capable of developing 8,000 hp.; a preliminary permit for project No. 32 in favor of the City of Dothan for a development involving 8,000 hp. at Chalkers Bluff, Geneva County, Ala., in the Choctawhatchee River, the application of the Huston Power Co. (Project No. 164) having been rejected as conflicting with the application of the City of Dothan; a license for project No. 77 in favor of the Snow Water and Power Co., for a development involving 15,000 hp. on the South Fork of Eel River in Lake County, California; a license for project No. 78 in favor of the Western States Gas and Electric Co., involving the enlargement of an existing project of about 10,000 hp. on the American River in Eldorado County, California.

Applications received by the commission during the two weeks ended July 16 are as follows:

James B. Girand, Gooding Bldg., Phœnix, Ariz.; preliminary permit; dam and power house, Colorado River at mouth of Andrus Canyon, Arizona; 130,000 hp.; public utility.

City of St. Paul, Minnesota; preliminary permit; power house at the government dam, Mississippi River at St. Paul; 16,000 hp.; public utility.

Mount Shasta Power Corporation, San Francisco, Cal.; preliminary permit; two projects, each consisting of dam, tunnel and power house on Pit river, Shasta County, Cal.; 114,000 hp.; public utility.

New Publications

THE ENGINEERING INDEX FOR 1921. Published by the American Society of Mechanical Engineers, 29 West 39th St., New York City. Cloth; 6¼ x 9¼ in.; 586 pages. Price, $6.

An index to notable articles printed in about 700 engineering and allied technical publications during 1920. It is stated in the preface that nearly 14,500 references are included. Periodicals from many different parts of the world are referred to, many of the articles mentioned being printed in foreign languages. The alphabetical or dictionary arrangement of subjects has been used in the 1920 volume as this method proved convenient and satisfactory in the 1919 edition. Each reference gives: Exact title of the article; the author's name (if given); the name of the periodical; the volume, number, and date of publication; the page numbers and number of figures of the article; and a brief summary of the article. Photostatic copies of the articles indexed are supplied at a small charge by the Engineering Societies Library in New York, where files of the publications are kept.

Personals

Edward R. Kowles, consulting engineer and fuel expert, has taken charge of the pulverized-coal and gas-fuel engineering work of Murrie & Co., Inc., of New York City.

Merton R. Sumner, formerly chief engineer of the Fuller Industrial Engineering Corporation, has been appointed chief engineer of Arthur D. Little, Inc., of Cambridge, Mass.

Linton K. Starr, assistant city editor of the *Atlanta Journal*, has resigned to become executive secretary of the newly organized Georgia Committee on Public Utility Information.

Edward A. Dieterle, who has been assistant chief chemist of the Koppers Co., Pittsburgh, is to be the chief chemist of the Chicago Byproduct Coke Co. The new plant will be in operation about September 1st to supply mixed coke-oven and water-gas to the Peoples Gas Light and Coke Co. as a portion of their city supply.

I. H. Lovett has been appointed assistant professor of electrical engineering at the University of Missouri. He was graduated in 1914 from Massachusetts Institute of Technology, served five years in the engineering department of the New England Power Co., and has recently been an instructor in electrical engineering at the Worcester Polytechnic Institute.

W. W. Odell, fuels engineer of the Bureau of Mines, is now in North Dakota, where he will co-operate with Professor Babcock, of the University of North Dakota, on an extended series of tests of lignite carbonization. The experimental work will be done in the small lignite coking plant of the university as part of the co-operative work of the Bureau of Mines and the university.

Dr. Harry A. Curtis, who has been with the International Coal Products Corporation as chief chemist, is now general manager of one of the subsidiaries of this company, known as the Clinchfield Carbocoal Corporation, South Clinchfield, Va. In this capacity he will have charge of the plant and industrial village owned by the corporation and will be responsible for the further development and operation of the carbonization plant using the Smith carbocoal process for the first time on a commercial scale in this country.

Miscellaneous News

The Power Administration Department of the California State Railroad Commission and the position of power administrator have been abolished. The office came into existence in June, 1918, as a war emergency measure for the regulation of the state's power resources. The commission has recommended that the work done by this department be continued by individual power companies.

A Hydro-Electric Plant of 4,500 kw. capacity is being put up by the New England Power Co., at Searsburg, Vt., on the Deerfield River about four miles from Wilmington. The new plant will have a net operating head of 215 ft. and will contain but one unit. The generator voltage will be 2,300 and the transmission voltage 66,000. The Power Construction Co., of Worcester, Mass., is in charge of the work.

An Industrial Relations Conference, which was authorized by Governor William C. Sproul of Pennsylvania, is being arranged by Dr. Clifford B. Connelley, Commissioner of the Department of Labor and Industry, Commonwealth of Pennsylvania, and will be held at Harrisburg, Oct. 24 to 27. The conference will include the features of the Welfare and Efficiency Conferences and Safety Congresses of previous years. The main topics to be discussed will include Industrial Waste, Industrial Co-operation, Industrial Publicity, Industrial Education, Women and Children in Industry and the Medical Supervision of Industry.

Business Items

The Economy Fuse and Manufacturing Co. has announced the resignation of A. F. Zacher as district manager of the Buffalo office.

The Algoma Steel Corp., Ltd., Sault St. Marie, Ont., Canada, has appointed **S. V. McLeod** purchasing agent in place of **L. L. Jacobs,** who recently resigned.

The Walworth Manufacturing Company, whose general offices have been at the Boston Factory, First and O Sts., Boston, has moved its general offices to Pearl and High Sts. The building takes in an entire block on High St.

The Canadian Chicago Bridge and Iron Co., Ltd., of Bridgeburg, Ontario, and Montreal, Quebec, has changed its corporate name to Horton Steel Works, Ltd., in honor of the late Horace E. Horton, who founded the organization in the United States in 1865.

The Bolinders Co., of New York, maker of marine and stationary oil engines, has opened a New England Branch at 53 State St., Boston, in charge of K. H. Nilsson, treasurer. A stock of engines and parts and a staff of erecting and operating engineers will be available.

The Judson C. Burns Sales Co., 1108-10 Walnut St., Philadelphia, Pa., has appointed C. H. Dudley sales instructor. Mr. Dudley was merchandise manager for the Toronto Hydroelectric System and Eastern representative for the American Electric Heater Co., of Detroit, Mich.

Chas. Cory & Son, Inc., 183-187 Varick St., New York City, have secured the manufacturing and selling rights for the Royer line of portable and stationary flow indicators, which are designed for indicating the flow of all kinds of corrosive and non-corrosive gases, vapors and liquids, and were formerly manufactured and sold by the A. H. Sloan Co., of Detroit, Mich.

The Malcolmson Engineering and Machine Corp. has been formed by the Malcolmson Briquet Engineering Co. and the St. Louis Briquette Machine Co. The new company will engage in manufacturing, will act as engineers and contractors for the building of complete power plants for fuel briquetting, peat harvesting, etc., and will maintain an engineering department devoted to the generation and use of steam, special furnace design and other heat problems.

Trade Catalogs

The Fulton Co., Knoxville, Tenn., manufacturer of "Sylphon" valves and regulators, has prepared a handy "Temperature Regulator Chart," the purpose of which is to show the exact size of the ccmpany's regulator required under given conditions.

The George J. Hagan Co., People's Bank Bldg., Pittsburgh, Pa., is distributing a new 9 x 11-in., 16'-page catalog on "Auxiliary Apparatus for Storing, Transporting and Conditioning Liquid Fuels." A number of interesting charts and diagrams is included.

The Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., has prepared an interesting 8½ x 11-in., 16-page booklet, "Operating History of Westinghouse Turbine Units of 30,000 Kw. and Higher." The details given of troubles encountered and methods of meeting them, operating records, etc., should make the book valuable to men in this line of work.

The Bigelow Co., New Haven, Conn., has recently gotten up two unusually attractive booklets, one 6 x 9 in., 48 pages, and one 9¼ x 13 in., 16 pages. The first of these contains a general description of the Bigelow boiler, details of construction, useful tables, specifications, etc., while the second, entitled "Quality," deals especially with methods used by the Bigelow Co. to insure high quality in its product.

The Tracy Engineering Co., 485 Sixth St., San Francisco, Cal., has prepared a 6 x 9-in., 24-page booklet entitled "Quality of Steam by the Throttling Calorimeter," which is not strictly a catalog, but is rather an explanation of the instruments and methods used in determining moisture in steam. The book goes into its subject with great thoroughness and contains a number of illustrations and tables.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoting	July 12 1921	July 19 1921
Pool 1,	New York	$3.10	$2.75@3.00
Pocahontas,	Columbus	3.25	3.00@3.25
Clearfield,	Boston	2.05	1.75@2.25
Somerset,	Boston	1.90	1.50@2.10
Pittsburgh,	Pittsburgh	2.10	2.00@2.15
Kanawha,	Columbus	2.15	1.75@2.25
Hocking,	Columbus	2.15	2.00@2.25
Pittsburgh No.8	Cleveland	2.25	2.15@2.25
Franklin, Ill.,	Chicago	3.15	2.50@3.50
Central, Ill.,	Chicago	2.40	2.00@2.75
Ind. 4th vein,	Chicago	2.50	2.25@2.75
Standard,	St. Louis	1.75	1.60@1.75
West Ky.,	Louisville	2.10	1.90@2.55
Big Seam,	Birmingham	2.15	2.00@2.25
S. E. Ky.,	Louisville	2.25	2.00@2.35

New York—On July 6, Port Arthur light oil, 22@25 deg. Baumé, 4½c. per gal. 30@35 deg., 5¼c. per gal. f.o.b. Bayonne, N. J.

Chicago—July 16, for 24@28 deg. Baumé, 45@55c. per bbl.; 32@34 deg. 1¼@1½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On July 18, f.o.b. refinery; Pennsylvania, 36@40 deg., 3¼c. to 3½c. Oklahoma, 24@30 deg. 45c. per bbl., gas oil, 32@34 deg., 1¼c. per gal., 36@38 deg., 1½c. 38@40 deg. 1¾c.

St. Louis—July 16, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 35c. per bbl.; 26@28 deg., 35c.; 28@30 deg. 40c.; 32@34 deg. 1¾c. per gal.

Philadelphia—On July 18, 26@28 deg., Baumé, Oklahoma, 50c. per bbl.; 30@34 deg., Oklahoma (group 3) 75c. per bbl.; 16@20 deg. Seaboard, 3¼c. per gal.

Cincinnati — June 27, for 22@28 deg. Baumé, 6½c. per gal.

Cleveland — June 27, for 22@28 deg. Baumé, 5c. per gal.

New Construction

PROPOSED WORK

Mass., Worcester—The Hotel Bancroft, Franklin St., is having plans prepared for a 10 story hotel addition on Portland St. About $1,000,000. Eisenwein & Johnson, 781 Ellicott Sq., Buffalo, N. Y., Archts.

Mass., Worcester — J. Rice, Archt, 306 Main St., is preparing plans for an 8 story, 92 x 113 ft. store and office building including a steam heating system on Waldo, Foster and Commercial Sts. About $500,000. Owner's name withheld.

R. I., Bristol—Guiteras Memorial School, S. P. Colt, Chrn. c/o The National India Rubber Co., Str. House and Allns Ave., having plans prepared for a 3 story school here. About $300,000. Clark & Howe, 1304 Turks Head Bldg., Providence, Archts.

Conn., Bridgeport—Davis & Dane, Archts., 1024 Main St., is receiving bids for a 2 story, 50 x 75 ft. cold storage plant and warehouse on Lineau Ave. for the City Dressed Beef Co. About $15,000.

Conn., Bridgeport—The Stratford Hotel, Main and Chapel Sts. is having preliminary plans prepared for an 8 story 60 x 90 ft. hotel addition. About $500,000. W. Schmidt, 1188 Main St., Archt.

Conn., Hartford—Hartford Seminary Foundation, 1507 Broad St., is having preliminary plans prepared for a school including a power house on Girard Ave. and Sherman St. About $1 000,000. Day & Klauder, 925 Chestnut St., Philadelphia, Pa., Archts.

Conn., Hartford—The Health & Charity Dept. will soon award the contract for a 2 story, 43 x 63 ft. central heating plant and laundry on Holcomb St. About $80,000. Whiton & McMahon, 36 Pearl St., Archts. Noted Mar. 22.

N. Y., New York—The American Academy of Arts and Letters Inc., c/o McKim, Mead & White, Archts., 101 Park Ave., is having plans prepared for a 3 story, 83 x 100 ft. educational building at 629 West 155th St. About $300,000.

N. Y., Oswego—J. A. Randall, Archt., S. A. & K. Bldg., Syracuse received bids for installing a steam heating system in the proposed 3 story high school on 1st St. from R. J. Sheehan, 16 south Center St., Schenectady, N. Y., $64,023. Power Efficiency Corp., White Bldg., Buffalo N. Y., $72,980. Ryan Plumbing & Htg. Co., 160 Court St., Watertown, N. Y., $73,100. Noted June 21.

N. Y., Perrysburg—Comr. of Buildings, Room 6, Municipal Bldg., Buffalo, will soon award the contract for a group of buildings to be used as a tuberculosis hospital here. About $1,200,000. H. L. Bec., Municipal Bldg., Archt. Noted Feb. 15.

N. J., Jamesburg — A. B. Mills, State Archt., 142 West State St., Trenton, will receive bids until July 28 for one 50 kw. 125 volt set making steam and exhaust connections engine, standard design, generator, wiring and switchboard, to be installed at the institution for Boys here. About $7,500.

N. J., Jersey City—Haring & Blumenthal, 1587 Bway., New York City, plans to build a theatre and office building on Jackson and Orient Aves. About $500,000. E. De Rosa, 110 West 40th St., New York City, Archt. Owner will build by separate contract.

N. J., Vineland—A. B. Mills, State Architect, 142 West State St., Trenton, will receive bids until July 28 for two standard design single or 4 valve, 100 lb. steam pressure engines, 2 72 kw. 110-220 volts, Standard type generator, wiring and switchboard to be installed in the Institution for Feeble Minded Women here. About $250,000.

Pa., Washington—George Washington Hotel Co., c/o W. L. Stoddart, Archt., 9 East 40th St., New York City, will soon receive bids for a 10 story hotel on South Main St. About $1,000,000.

Md., Baltimore—Church Home & Infirmary, North Bway., is having plans prepared by Wyatt & Nolting, Archts., Keyser Bldg., for a 6 story, 86 x 126 ft. hospital addition including boiler room, etc., on Bethel St.

Md. Baltimore—The National Bank of Baltimore, Baltimore and St. Paul Sts., is having preliminary plans prepared for a 15 story bank and office building. About $2,000,000. F. A. Fletcher, 507 North Charles St., Archt.

Md., Baltimore—The University of Maryland will receive bids about August 1 for a 6 story, 35 x 75 ft. nurses home including a steam heating system on Lombard & Green Sts. Flournoy & Flournoy, 306 St. Paul St., Archt.

D. C., Washington—A. L. Flint, General Purchasing Officer of the Panama Canal will receive bids until August 3 for three 110 and 220 volt, 25 cycle, single phase, repulsion induction, 3 hp. motors and two 14 ft. electrically driven centrifugal sewage pumps.

N. C., Greensboro—J. I. Foust, Pres. N. C. College for Women, will receive bids until August 5 for 3 dormitories and addition to the McIver building including steam heating system on campus. About $350,000. H. Barton, Archt.

La., New Orleans — The Bd. of Port Comrs., Room 332, New Orleans Court Bldg., plans to install 5—50 hp. electric motors on the new Marine Wharf now under construction.

La., Westwego—F. T. Payne, Engr., Jefferson Bank Bldg., Gretna, will receive bids until August 8 for the installation of a water-works system including piping, water tower, pumps, etc.

Tenn., Nashville—The Vanderbilt University plans to build 1-2-3 and 4 story medecine buildings on campus here. About $4,000,000. J. H. Kirkland, Pres., 21st Ave. Coolidge & Carlson, 89 State St., Boston, Mass., Archts.

Ky., Dawson Springs—Treasury Dept., J. A. Wetmore, acting supervising Architect, Washington, D. C. received bids for an out door electric sub-station at the Public Health Hospital here from—Hoosier Engineering Co., 208 Saks St., Indianapolis, Ind., $7,365; Strang Electric Co., 214 South 7th St., Philadephia, Pa. $7,120; McCarthy Bros. & Ford, 75 West Mohawk St., Buffalo, N. Y., $7,950. Noted July 12.

O., Alliance—M. M. Mansfield, Clk. Bd. Educ., will receive bids until August 8 for a 2 story school on South Liberty St. About $300,000. F. L. Packard, New Hayden Bldg., Columbus, Archt.

O., Cleveland—The Hotel Parkway Co., c/o M. Weis, Archt. 618 Union Bldg., plans to build an 8 story hotel including a steam heating system at 2026 East 107th St. About $1,00,000.

Mich., Battle Creek—The Bd. Educ. will soon award the contract for a 3 story vocational school including a steam heating system. About $500,000. J. D. Chubb, 109 North Dearborn St., Chicago, Ill., Archt. Noted May 3.

Mich., Detroit—H. Silverman, 1030 Penobscot Bldg., plans to build a 4 story apartment including vapor heating system on Second Blvd. and Canfield St. About $250,000. M. H. Finkel, 333 Majestic Bldg., Archt.

Ill., Chicago—The Daughters of Zion Infants Home and Day Nursery, 1441 Wickes Park Ave., will soon receive bids for superstructure for a 3 story, 96 x 278 ft. infants home and auditorium including a steam heating system on Hirsch Blvd. and California Ave. About $275,000. Dunkin & Eisenberg, 14 West Washington St. Archts.

Ill., Chicago—E. Grossman, Archt., 631 North Michigan Ave., will soon award the contract for the first unit of a 12 story, hospital including a steam heating system at 460 East 23d St., for the Womens Hospital, 25 East Jackson Blvd. About $500,000. Noted April 26.

Ill., Jerseyville—The City is having plans prepared for a reservoir, pumping station, etc. About $75,000. Fuller & Beard, Chemical Bldg., St. Louis, Mo., Engrs.

Wis., River Falls—The City, c/o G. Smith, Mayor, plans to install a new water work system including filtration plant, new pumps and mains. About $20,000. J. H. A. Brahtz, 409 Metropolitan Opera House Bldg., St. Paul, Minn., Engr.

Ia., Corning—The City plans to build a 42 x 42 ft. electric light plant on Adams St. About $60,000. C. K. Munns, Engr.

Minn., Fairbault—The St. Louis Hospital, T. Kettelbut, Supt., will receive bids until Aug. 2, for a 4 story, 44 x 101 ft., hospital including boiler house and laundry. About $150,000. Schippel & Schmidt, Krauss Bldg., Mankatom, Archts. Noted July 19.

Minn. Mankato—The city will receive bids until Aug. 2, furnishing 8 in., 2 stage, horizontal split case centrifugal pump with 1,750,000 gal. capacity in 24 hrs., and one electric 150 hp. slip ring motor, 3 phase, 2,300 volt, 60 ampere 1,800 r.p.m., f.o.b. Mankato.

Minn., Park Rapids—The city plans to build waterworks extensions and pumping station. About $30,000. Bradley Eng. Service Co., St. Cloud, engrs.

Kan., Derby—The City, c/o J. J. Butterfield, is having plans prepared for a water works system including reservoir, pipe line and pumping station. About $25,000. W. B. Rollins, Ry. Exch. Bldg., Kansas City, Mo., Engrs.

Kan., Dexter—The City plans to remodel electric light plant and build 19 mile transmission line to Winfield. W. B. Rollins Engr. Co., Railway Exch. Bldg., Kansas City, Mo., Engrs.

Kans., Parsons—The City will soon receive bids for water works improvements including rebuilding power plant, filter equipment and machinery of 6,000,000 gal. capacity. About $500,000. Burns & McDonald, 400 Interstate Bldg., Kansas City, Mo., Engrs.

Neb., Lincoln—The Bd. Educ. will receive bids until Sept. 6 for a 2 story, 120 x 195 ft. school, on 25th and North Sts. About $400,000. Fiske & McGinnis, Banker Life Bldg., Archts. Noted June 14.

Mo., Kansas City—The Liberty Memorial Association plans to build a memorial building opposite Union Sta. About $2,000,000. H. Van Buren Magonigle, 101 Park Ave., New York, N. Y., Archt.

Tex., Dallas—M. G. James, City Sec'y. will receive bids until August 12 for a water purification plant at White Rock reservoir including one 10 million gals. per day, 60 ft. head and a 2,900 gals. per min., 150 ft. head, centrifugal pumps, both turbine driven with waterworks type condenser.

N. S., Sydney—The City Council authorized the purchase of a pump for water works service. About $25 000.

N. B., St. John—The Bd. Pub. Wks., Ottawa, will receive bids until Aug. 8, for a power, disinfecting and bath house at Quarantine Station. R. C. Desrochers, Secy.

Que., Montreal — Administration Comn. will receive bids until August 5 for one 12 million gallon pump for the McTarish St. pumping Station. Water Board Comn., Notre Dame East, Engr.

Que., Quebec City—The Quebec Development Co., c/o W. Price, Pres., 145 Grande Alle Ave., is having plans prepared for developing water power, utilizing the Lake St. John Power Resources in Lake St. John Dist. About $3,000,000. Running Streams Comn. 54 Notre Dame, Montreal, Engrs.

B. C., William Head—The Dept. of Pub. Works, Ottawa, R. C. Desrochers, Secy., will receive bids until Aug. 5th for oil engine and generator at Quarantine Station here.

CONTRACTS AWARDED

Mass., Falmouth—The Water Commissioners have awarded the contract for the installation of 2 H. R. T. boilers to Walworth-English-Flett Co. 100 Pearl St., Boston, Mass. About $12,979. Noted March 29.

Mass., Northampton—The Smith College, Bd. of Trustees, has awarded the contract for three 3 story, 40 x 200 ft. dormitory buildings on Paradise Rd. to J. P. Keatting, Westboro, and the heating system to Cole Pheeps Htg. Co., Holyoke. Total cost about $700,000.

Mass., Watertown—The City has awarded the contract for a 3 story, 90 x 220 ft. high school to M. W. Ryan, Central Sq., Cambridge. About $250 000.

N. Y., Brooklyn—Cushman Sons, Inc., 49 Manhattan St., New York City, has awarded the contract for a 4 story, 50 x 200 ft. bakery including a steam heating system on Atlantic Ave. near Troy Ave. to Levering & Garrignes, 552 West 23rd St., New York City. About $250,000.

N. Y., New York—R. H. Davis, 3 East 43rd St., has awarded the contract for a 16 story, 50 x 100 ft. loft including a steam heating system on 66-70 West 40th St. to Leddy & Moore, 105 West 40th St. About $500,000.

N. Y., Rochester—W. Barsch, 1063 St. Paul St., has awarded the contract for a 9 story, 150 x 160 ft. apartment hotel on East Ave. to E. V. Johnson Co., 20 West Jackson St., Chicago, Ill. Steam heatng system will be installed. About $2,000,000.

N. J., East Orange—The Ward Baking Co., Southern Blvd., New York City, has awarded the contract for a 5 story bakery and garage to J. W. Ferguson Co., United Bank Bldg., Paterson. Steam heating system will be installed. About $500,000.

Miss., Starkville — The Mississippi Agriculture College has awarded the contract for 1 and 2 story power house to Estes, Williams & Ragsdale, Seimitor Bldg., Memphis, Tenn. About $50,000. Noted July 12.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., has awarded the contract for a 2 story high school addition on Parkwood Dr. and Everton Ave. to W. Moore Co., 1274 West 4th St. Contract for a steam heating system was awarded to Feldman Bros., Barret Ave. Total cost about $300,000.

O., Maple Heights (Bedford P. O.)—The Bd. Educ. has awarded the contract for installing heating plant in Broadway school here to The Industrial Heating Co., 301 Ohio Bldg., Akron, $24,996. Noted June 14.

Mich., Battle Creek—The Bd. Educ. has awarded the contract for a 3 story, 95 x 400 ft. vocational school and a 60 x 80 ft. steam heating plant to R. G. Phelps. About $400,000.

Mich., Ecorse—The Hinkley Motor Corp., 3420 West Fort St. Detroit, has awarded the contract for a 1 story, 250 x 340 ft. factory and a 50 x 62 ft power house on Cicotte Ave., to H. G. Christman Co., Stevens Bldg., Detroit. Noted July 5.

Ill., Chicago—The Melrose Hotel Co., c/o J. A. Nyden, Archt., 190 North State St., has awarded the contract for a 7 story, 90 x 165 apartment hotel including a steam heating system on Melrose St. and Sheridan Rd. to J. E. Mahlin, 1442 Farragut Ave. About $750,000. Noted May 3.

Ill., Freeburg—The City, c/o Rehnsimer, has awarded the contract for an electric light plant to Klein Constr. Co., generators to the Western Electric Co., 810 Spruce St., St. Louis, Mo., boilers to F. C. Schwaner Mch. Co., St. Louis, Mo., and engines to Chuse Engine Co., Mattoon. Total cost about $25,000. Noted June 14.

Ill., Highland Park—The Presbyterian Home for Aged, 225 South Johns Ave., has awarded the contract for a 3 story, 35 x 400 ft. home to W. Adams Co., 209 South LaSalle St., Chicago, Ill. Steam heating system will be installed. About $300,000.

Wis., Janesville — The Bd. Educ. has awarded the contract for a 3 story, 180 x 210 ft. high school and a 40 x 50 ft. boiler house on South Main St. to J. P. Cullen & Sons, $513,813. Noted June 28.

Ia., Council Bluff—The J. Edmundson Hospital Assn. has awarded the contract for a 4 story, 44 x 128 ft. main hospital bldg., with two 30 x 50 ft. wings on Oak and Pierce Sts. to Parsons Constr. Co., 616 Keeling Bldg., Omaha, Neb. Bids will be received later on heating system.

Ia., Mason City—The City, c/o H. D. Pool, has awarded the contract for a storage reservoir, enlargement of pumping station and extending water main to J. A. McDonald Constr. Co., 752 Builders Exch., Minneapolis, Minn. About $300,000.

Mo., St. Louis — The Thirty-sixth St. Realty Co., 111 North 7th St., has awarded the contract for a 12 story apartment hotel on Grand and Lindell Sts. to P. J. Bradshaw, International Life Bldg., Archt. About $1,000,000. Architect builds and sublets.

Ont., Hamilton—The Hospitl Bd., c/o Dr. W. F. Longrill, has awarded the contract for a 5 story, 45 x 175 ft. nurses home on Barton St., E., and Eucled Ave., to W. H. Yates Constr. Co., 17 Main St., E. Vacuum steam heating system will be installed. About $300,000. Noted July 12.

Ont., Sturgeon Falls—The Town Council has awarded the contract for waterworks, pumphouse and sanitary sewers to McNamara Bros. & Thornton, Saulte Ste Marie. About $70,000.

N. M., Ft. Stantion—The Bureau of Yards and Docks, Treas. Dept. Wash., D. C., let contract for repairs to boilers at sanatorium here, to C. J. Gleason, 125 North Chandler St., Augusta, Ga. $2,939.